# SNARE HYDRO SYSTEM

# 2006
# Comprehensive Dam Safety Review

## FINAL

**Prepared for:**

NORTHWEST TERRITORIES POWER CORPORATION

**By:**

Klohn Crippen Berger

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# EXECUTIVE SUMMARY

A Comprehensive Dam Safety Review (DSR) of the Snare Hydro System was performed by Klohn Crippen Berger Ltd. (KCBL) between July and December 2006. The DSR was performed in accordance with Section 2 of the Canadian Dam Association, Dam Safety Guidelines.

The Snare Hydro development is a cascade of four facilities: Snare Rapids; Snare Falls; Snare Cascades and Snare Forks. All four facilities were assessed in the DSR.

The previous DSR was performed in 2000. The current DSR assesses changes since the 2000 DSR.

The Consequence categories, which determine the magnitude of imposed loadings that the structures must safely withstand, were reviewed for Snare Rapids, Snare Falls and Snare Forks and found to be unchanged from the previous DSR - High for both normal operation and floods. The Consequence category for Snare Cascades does not appear to have been previously determined. The consequence category for this facility was reviewed in accordance with both the BC Dam Safety Regulation and the CDA Dam Safety Guidelines. Snare Cascades is rated High for both normal operation and floods.

The 1,000 year annual exceedance probability (AEP) flood is the appropriate Inflow Design Flood (IDF) for the Snare Hydro development. The spillways at Snare Rapids, Snare Falls, Snare Cascades and Snare Forks have sufficient capacity to pass the current estimate of the IDF.

An earthquake having an annual exceedance probability of 1 in 1,000 years is the appropriate maximum design earthquake (MDE) for the Snare Hydro development. The Geological Survey of Canada (GSC) has performed a detailed review of the seismicity of Canada and revised their seismic hazard maps for the 2005 National Building Code of Canada. The latest GSC data was considered for this DSR.

The condition of each of the structures is described in the report, including observations made during a site inspection in July 2006. Operation, maintenance, surveillance and emergency preparedness were also reviewed.

A detailed evaluation of the structures against the requirements of the Dam Safety Guidelines is summarized in the Appendices. Non conformances (procedural, operational and maintenance aspects) and potential deficiencies (physical aspects or conditions that could potentially threaten structure safety) were identified, prioritized for scheduling purposes, and are summarized in tables in the report.

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## FIGURES



## APPENDICES

# 1. INTRODUCTION

This report presents the results of a Dam Safety Review (DSR) of the Snare Hydro development (Snare Rapids, Snare Falls, Snare Cascades, and Snare Forks), performed by Klohn Crippen Berger Ltd. (KCBL) for Northwest Territories Power Corporation (NTPC). The DSR was performed in general accordance with the Dam Safety Guidelines of the Canadian Dam Association (1999). The work was performed under NTPC's Consulting Agreement Contract No. 436206 dated 16 June 2006. NTPC issued a Request for Proposal No. 20605 – "Dam Safety Review Audit, Snare Hydro" in April 2006, Addendum No. 1, dated May 8, 2006 and Addendum No. 2, dated 12 May 2006. KCBL submitted its proposal on 17 May 2006. These documents form the basis of the consulting agreement.

The previous DSR was performed in 2000 (Agra Monenco, 2000). This current report describes the changes observed since the 2000 DSR and should be read in conjunction with that earlier report. Drawings and specifications of the existing facility were not available at the time of the site inspection. The primary source of facility layout information was obtained from figures included with previous reports that have subsequently been adopted into this DSR report.

Maintenance and other items identified during the site inspection that are not considered to be dam safety related will be described in a separate letter to NTPC.

The Snare Hydro development consists of Snare Rapids, Snare Falls, Snare Cascades and Snare Forks and has a combined capacity of 29 MW, supplying a significant portion of the power for the communities in the North Slave area, including Yellowknife, Dettah and Rae-Edzo. The regional location plan of the Snare Hydro development is shown on Figure 1-1 and the facilities layout is shown on Figure 1-2. Note that these figures are out of date (Snare Cascades is not shown) and should be updated.

Construction of Snare Rapids began in 1946 and was completed in 1948. It is the most upstream facility in the cascade, impounding Big Spruce Lake. The Snare Rapids facility is comprised of a zoned earthfill embankment dam, a spillway located approximately 6 km from the main dam, two side dams and a powerhouse intake, tunnel and powerhouse.

Snare Falls is located approximately 15.5 km downstream of Snare Rapids. Constructed in 1960, the Snare Falls facility is comprised of the powerhouse, main dam, two saddle dams, a gated spillway and an overflow weir. The Snare Falls forebay extends to the tailrace of Snare Rapids.

The newest plant in the cascade is Snare Cascades, which is located approximately 3 km downstream of Snare Falls. The Snare Cascades development was constructed in 1996 and includes a powerhouse, power canal and labyrinth spillway. The power canal is formed partially in rock cut and partially by rockfill dykes. Snare Cascades is essentially a run-of-river facility.

The most downstream plant in the Snare Hydro scheme is Snare Forks, which includes two dams, Strutt Lake Dam and Snare Forks Dam, three freeboard dykes and a fixed elevation spillway. Strutt Lake is located about 0.5 km downstream of the Snare Forks Dam. The tailrace is a channel excavated through bedrock connecting the dam to Strutt Lake.

# 2. SITE INSPECTION

Site inspections took place from 12 to 14 July 2006 as follows:

- 12 July: Snare Rapids;
- 13 July: Snare Falls and Snare Forks; and
- 14 July: Snare Cascades.

The KCBL inspection team consisting of Ryan Douglas, P.Eng., (geotechnical), Dirk Duivestein, P.Eng., (structural) and Graham Stranks, P.Eng., (mechanical) traveled from Yellowknife to the Snare Hydro system via chartered aircraft on the morning of 12 July and returned on afternoon of 14 July. The team was accompanied by NTPC's project manager, Colin Stang, P.Eng. and Ken Dies, the Systems Controls and Operations manager. Accommodation for the inspection team was provided by NTPC at the Snare Rapids staff house.

The weather during the visit was generally warm and sunny with some cloudy and windy spells.

At the time of inspection, Big Spruce Lake was at EL. 222.0 m (EL. 728.20 ft) with approximately 142 $m^3/s$ (5,000 cfs) being discharged through Spillway 5B. Water levels throughout the entire system were generally high and all four powerhouses were in operation.

Inspection check lists are presented in Appendix I. Representative photographs are presented in Appendix II.

# 3. CONSEQUENCE CATEGORY

## 3.1 Snare Rapids, Snare Falls and Snare Forks

The previously assigned consequence categories of High for Snare Rapids, Snare Falls and Snare Forks with respect to both floods and normal operation are still considered appropriate. There have been no developments or changes since the 2000 DSR that would result in a change of classification.

## 3.2 Snare Cascades

The consequence classification for Snare Cascades was not evaluated during the previous DSR (Agra Monenco, 2000). It is located upstream of Snare Forks and downstream of Snare Falls plants, both of which are classified as High consequence category facilities. The results of the dam break inundation study undertaken during the 2000 DSR concluded that the incremental consequence of failure of both Snare Falls and Snare Forks for loss of life and environment impact would be low while with respect to socio-economic losses would be high due to high direct and indirect costs related to being out of service and replacing the plants.

Snare Cascades is a run-of river facility and is located between two facilities with significantly greater storage potentials. Therefore by deduction, its incremental consequence of failure with respect to loss of life and environment can be no greater than that for the plants upstream and downstream of it and is also low.

The direct and indirect costs for lost generation during reconstruction plus the design and construction cost of a replacement dyke in the event of a Snare Cascades failure is estimated to be greater than $1 million, based on preliminary cost estimates for comparative work carried out for the Twin Gorges expansion project (KC, 2005) and estimates of loss of power sales as a result of a prolonged outage. According to the British Columbia Dam Safety Regulations (BC, 2000) a dam should be considered to be a High consequence dam if the economic consequences of failure are between $1 million and $100 million. Therefore the incremental consequences of failure with respect to economic impacts are high.

For this combination of consequence factors Snare Cascades is assessed to fall within the lower range of the High category with respect to both normal operation and floods in accordance with the CDA classification guidelines.

# 4. INFLOW DESIGN FLOOD

## 4.1 Annual Recurrence Interval Assessment

The previous DSR determined the 1,000 year annual exceedance probability (AEP) flood to be the appropriate design basis for Snare Rapids, Snare Falls and Snare Forks based on the assessment that the Snare facilities fall into the lower range of the High consequence category. There have been no developments or changes since the 2000 DSR that would result in a change to the previously assessed annual recurrence interval IDF.

This same standard is subsequently adopted for Snare Cascades based on the incremental consequences of failure discussed in Section 3.

## 4.2 Flood Frequency Analysis

An updated flood frequency analysis was carried out as part of the current DSR using the HydroFreq software, which plots the data on Generalized Extreme Value, 3 parameter Log-Normal, Log Pearson Type III and Pearson Type III distributions, incorporating additional flow data recorded since 1999. All four distributions provided close fit to the historic data at low to medium return periods but were somewhat divergent at the higher return periods. This divergence can be significant as the 1,000 year flood is determined by extrapolating from the measured data. The 1,000-year flow was estimated by taking the average of the four distributions. The estimated updated 1,000-year IDF is 535 $m^3/s$, practically unchanged from the value of 540 $m^3/s$ determined in the 2000 DSR (Agra Monenco, 2000). Due to the divergence in the above noted distributions, there is uncertainty in this value. The similar value obtained for the updated IDF estimate is expected considering the lack of any significant hydrological events occurring since the previous estimate in the 2000 DSR.

As discussed in the 2000 DSR report, the existing spillways of the Snare Rapids, Snare Falls and Snare Forks facilities have the capacity to safely pass the 1 in 1000 year routed IDF (spillway design flood) of 457 $m^3/s$ and freeboard at the dams, based on design crest and core levels, is more than adequate for waves and run-up resulting from combinations of wind and floods up to the 1,000 year AEP events (annual probabilities of occurrence = 0.001).

The capacity of the free-flow labyrinth spillway at the run-of-river Snare Cascades G.S. was not evaluated in the previous DSR. Due to its small incremental catchment area and negligible flood peak attenuation potential, it is considered appropriate to adopt the same routed IDF of 457 $m^3/s$ as per the other Snare Hydro plants.

Figure 4-1 illustrates the spillway rating curve for Snare Cascades. It is evident that the Snare Cascades labyrinth spillway has the capacity to safely pass the 1 in 1000 year routed IDF of 457 $m^3/s$. The top of the concrete cut-off in the Approach Channel Dyke is EL. 184.5 m.

# 5. MAXIMUM DESIGN EARTHQUAKE

An evaluation of the Maximum Design Earthquake (MDE) does not appear to have been made in the previous DSR. In the Design Review report (Agra Monenco, 2000b), which was part of Phase 1 of the 2000 DSR, the Snare Hydro projects were considered to be located in a zone of low seismicity (Zone 0 from the National Building Code of Canada). The authors of the 2000 DSR considered the earthquake effects in Zone 0 to be negligible and not control design. However, the MDE per se was not determined as far as we know.

The CDA Guidelines require that a dam be evaluated for its ability to withstand the ground motions associated with the MDE. For a High consequence structure, the appropriate MDE would range from 50% to 100% of the Maximum Credible Earthquake (MCE) if derived deterministically, or the earthquake with an AEP ranging from 1/1,000 yr to 1/10,000 yr if derived probabilistically.

The Geological Survey of Canada (GSC) has recently reviewed the seismicity of Canada and revised its seismotectonic models, particularly the maximum magnitude of earthquake that might be expected, for inclusion in the 2005 edition of the National Building Code of Canada. Table 5.1 summarises the site specific peak firm ground accelerations (PGA) for various annual exceedance probability events determined for the Snare Hydro projects, based on the GSC's seismic hazard model of Canada (see Appendix III).

Considering the relatively low consequences regarding life safety and environmental impacts resulting from failure, the 1,000 year earthquake (3.5% g) is assessed to be the appropriate MDE for Snare Hydro projects.

Table 5.1 – Snare Hydro peak firm ground acceleration (PGA)

| **Annual Exceedance Probability (AEP)** | **Recurrence Interval (years)** | **PGA (g)** |
|---|---|---|
| 0.01 | 100 | 0.007 |
| 0.0021 | 475 | 0.021 |
| 0.001 | 1,000 | 0.035 |
| 0.000404 | 2,475 | 0.059 |

# 6. SNARE RAPIDS

## 6.1 General

Snare Rapids development (Figure 6-1) which impounds the Big Spruce Reservoir is the oldest of the four developments that NTPC operates on the Snare River. It is the uppermost plant in the cascade and controls the water released through the system. Big Spruce Reservoir was created by raising the levels of Big Spruce Lake and Kwijenne Lake from their natural levels of EL. 207.3 m (EL. 680.1 ft) and EL. 210.1 m (689.3 ft) respectively to the development's current licensed normal maximum operating level (MOL) of EL. 222.3 m (EL. 729.3 ft). Note that the maximum normal operating level shown on the available drawings of EL. 222.19 m (EL. 729.0 ft) (see Figure 6-2) is inconsistent with what is reported in the OMS manual. The key components of the Snare Rapids development include the main dam; intake, power tunnel and powerhouse; Spillway 5B and Side Dam 5B located about 5 km southeast of the main dam; and Side Dams 4 and 9B which close topographic lows around the reservoir rim.

## 6.2 Main Dam

### 6.2.1 General

Snare Rapids main dam is a zoned earthfill embankment dam with a crest length of 220 m and maximum height of 21 m founded on granite of the Canadian Shield. The dam has a central core of uniformly graded fine silt, sand filters and coarse sand shells with 0.6 m of riprap erosion protection on the upstream face and rockfill erosion protection downstream. The design crest level of the dam is at EL. 224.02 m (EL. 735.0 ft) with the original top of the core designed to be at EL. 222.50 m (EL. 730.0 ft), 0.3 m above MOL and with 1.6 m (5 ft) of granular frost protection. The design provides 1.83 m (6.0 ft) of freeboard to the top of the dam. The upstream and downstream shells are sloped at 3H:1V and 2H:1V respectively.

### 6.2.2 Operational Performance

The silt used for the core was “semi-liquid” (moisture contents approached the liquid limit) during dam construction. It is reported that there was some cracking of the crest several years after impoundment, however the cracks were filled with sand and have not reappeared. Investigations undertaken as part of the 2000 DSR revealed that post construction settlements of the core had been in the order of 3% of the height of the dam fill and that the reservoir was being routinely operated above the top of the dam core for extended periods of time. It was recommended that NTPC consider raising the core to above MOL level to reduce the potential for long term deterioration and performance problems. In 2002 the core was raised by approximately 1.0 m to a nominal elevation of EL. 223.0 m (EL. 731.6 ft). The new as-built profile is presented in Figure 6-2. Reference drawings such as Figure 6-1, should be updated to illustrate the current arrangements.

NTPC staff report no significant performance problems and the 2000 DSR found the dam to be in good condition.

### 6.2.3 Current Condition

The main dam was inspected on 12 July 2006. The water level in the Big Spruce Reservoir was at EL. 221.96 m (EL. 728.20 ft), 0.3 m below licensed maximum operating level, exposing approximately 2 m of the upstream face.

The crest of the dam appears planar with no visible cracking or settled areas (Photo 1). At the time of inspection the crest had recently been graded, making observation of any older cracking or other signs of distress impossible, but NTPC staff reported that the discontinuous longitudinal cracking near the upstream crest noted in some winters since 1990, and which has been attributed to ice lens formation in the frost-susceptible silty sand (20% silt typically) filter covering the top of the core, has not re-occurred. Notwithstanding the appearance of the crest, it is noted that based on the crest survey undertaken following the core raising remedial works (see Figure 6-2) there are several areas where the crest is below the design level either as a result of local settlement or lack of placing sufficient material following the core raising remedial works. The most deficient area is near the right abutment where the crest is locally up to 260 mm (0.85 ft) below the designed top of dam. Although the crest level is still above the minimum elevation of EL. 223.34 m (EL. 732.7 ft) required to satisfy the latest freeboard estimates (Agra Monenco, 2000) at all locations, it is recommended that the dam crest design level be reinstated over the full length of the dam and confirmed by a new crest survey.

Minor vegetation is starting to become established along the crest shoulders and upstream and downstream slopes of the dam crest which should be removed while it is still small enough to do so easily (Photo 2).

The riprap on the upstream face of the dam is generally in satisfactory condition, with no significant signs of deterioration, beaching or erosion damage. There are some localized areas where larger size particles appear lacking, but are somewhat masked by the presence of much finer material which falls over the crest shoulder during grading operations. No remedial work is currently recommended, but the condition should be monitored in the future to detect any deterioration. The additional riprap placed between the intake and right abutment prior to the 2000 DSR appears to be performing adequately with no signs of deterioration.

There are fairly regular accumulations of woody debris along the upstream face of the dam (Photo 2 and 3) which has the potential to dislodge the riprap during periods of high wind and waves. This material should be removed when brushing of the crest and slope is next undertaken to prevent deterioration of the riprap protection.

The downstream face of the dam is planar with no erosion gullies, signs of instability, or visible seepage from the toe or abutments (Photo 4). Saplings and smaller vegetation establishing itself in the downstream shell of the dam should be removed prior to becoming fully established when it can become problematic due to potentially masking areas of distress which would otherwise be visible.

Minor seepage from the downstream left abutment occurring since commissioning and which is collected in a heated sump between the toe of the dam and the staff house (Photo 5) was not occurring at the time of inspection, although there was water ponded in the invert of the sump. NTPC staff advised seepage shows no significant changes and is typically in the order of 1 L/min.

The exposed bedrock at the dam abutments is strong to very strong massive gneiss, with widely spaced discontinuities and no signs of seepage.

### 6.2.4 Instrumentation and Monitoring

In 2000, a single multi-level thermistor was installed in the top 6 m of the main dam to record temperature fluctuations at 0.5 m intervals in the top of the dam and core. Figure 6-3 charts the data presented in Appendix IV. From Figure 6-3, frost penetration extends approximately 2 to 2.5 m (6.5 to 8 ft) into the upgraded core of the dam. However, laboratory testing and material assessments undertaken during the 2000 DSR concluded that the existing core material has low to negligible frost sensitivity due to its relatively high clay content (50 to 70% fines and 17% clay content) and consequent low permeability. Properties of the materials used to increase the height of the core were not available for review, but are assumed to have similar frost sensitivity properties. Although deterioration from freeze-thaw effects is unlikely based on the previous assessment, it is recommended that seasonal readings (4 per year) should be maintained as a minimum to confirm that no adverse conditions develop in the upper part of the dam and core which could potentially lead to deterioration. To this end it is noted that only 2 thermistor readings have been taken since June 2002.

### 6.2.5 Stability

The stability of the main dam under normal service and extreme loading conditions was checked during the 2000 DSR and verified as complying with current CDA guidelines and USBR/USACE design criteria. Material shear strength properties used for the analyses were not reported and the MDE is not explicitly stated, but is inferred to have been taken as the 475 year earthquake based on Zone 0 from the National Building Code.

As discussed in Section 5, the appropriate MDE is assessed to be the 1,000 year AEP event, which results in a peak acceleration approximately 67% greater than a 475 year event based on the latest GSC seismic hazard model of Canada (see Appendix III).

The increase in adopted MDE results in increased loading on the dam requiring a re-evaluation of the dam stability. Stability of the dam was re-assessed for both the normal and seismic load cases using SLOPE/W software (GeoSlope 2004) adopting conservatively assumed material strength properties and piezometric levels as no information was available to confirm the assumptions. The following strength properties were adopted for the stability review:

**Table 6.1 –** Assumed strength properties for stability assessment

| Material Type | Unit Weight ($kN/m^3$) | Shear Strength | |
|---|---|---|---|
| | | $\phi$ (degrees) | c (kPa) |
| Rockfill | 19.5 | 40 | 0 |
| Coarse Sand | 18 | 36 | 0 |
| Fine Sand | 18 | 34 | 0 |
| Core material (compacted silt) | 18 | 22 | 25 |

As illustrated on Figure 6-4 and Figure 6-5, the factors of safety for both the static and seismic load cases are considered to be satisfactory.

### 6.2.6 Summary

The Snare Rapids main dam appears to be in generally satisfactory condition with no evidence of deterioration or developing performance problems since the last DSR. The design crest elevation should be reinstated across the full length of the dam axis and resurveyed for verification and use for future comparison. Riprap on the upstream face should be monitored with particular attention to areas where sizes appear smaller than elsewhere. Local brush along the crest, upstream face and downstream face of the dam should be removed while it is still easy to do so and before the vegetation becomes well established and detrimental to the fills. The accumulations of woody debris on the upstream face of the dam should be removed at the same time brushing of the slopes and crest is undertaken. Seasonal readings of the core thermistor should be reinstated and data processed to ensure no changes to existing conditions.

## 6.3 Intake

### 6.3.1 General

The concrete intake structure is founded on bedrock as illustrated on Figure 6-1. The gate hoist is housed within a sheet steel insulated enclosure on top of a reinforced concrete substructure (Photo 6). A foot bridge is provided for access as the gatehouse is approximately 5 m. offshore. The foot bridge has proper handrails and is in good condition. The gatehouse has power and communications to the control room.

### 6.3.2 Operational Performance

The 2000 DSR (AGRA Monenco, 2000) described the reinforced concrete substructure as generally in good condition with some minor spalling and concrete deterioration primarily around the waterline. In addition, several hairline cracks had been observed which were recommended to be monitored. The report also referred to a previous underwater inspection by others in 1998 that indicated some corrosion and pitting of the trashrack steel.

The gate appears well maintained and no operating problems were reported. The Intake gate is tested yearly at the start of the regular annual maintenance shutdown. Test and maintenance records are located in Yellowknife and were not available for review at site.

### 6.3.3 Current Condition

During the 2006 DSR inspection, the high water level, EL. 221.96 m (EL. 728.20 ft) limited the inspection of the substructure. Where accessible, medium to large (rather than previously described "hairline") cracks were observed in the substructure. Attempts to repair some cracks with a light yellow patching material were unsuccessful as the patching material has also suffered spalling. The cracks are becoming more of a concern but at this stage are still considered a maintenance issue. Other than the cracks, the visible aspects of the reinforced concrete substructure appear sound.

The insulated sheet steel enclosure is functional but is being considered for replacement by NTPC. The creosoted timber access bridge appears in sound condition.

### 6.3.4 Electrical and Mechanical Equipment

The Intake gate is not used to pass flood flows, but the plant may be operated during flood events to discharge normal rated flows (max. 52.8 $m^3/s$). The failure of the intake gate to open is not a dam safety issue. Failure of the intake gate to close in the event of a penstock or power tunnel breach is a dam safety issue. Operating staff advised that emergency closure testing of the intake gate is performed annually, from the local and remote control system on alternate years. The testing and maintenance records are in the NTPC Yellowknife office (per the OMS manual) and were not available for review during the site visit.

Both electrical and mechanical equipment in the gate house appeared in good condition. The submerged gate could not be inspected but was reported to be in good condition. The location of the gatehouse offshore of the dam means that a mobile crane is required to lift the intake gate out of its slot for a complete inspection, requiring removal of the intake superstructure roof. There is no record of this being done since original installation, but there have been inspections by divers and through the dewatered penstocks at various times.

### 6.3.5 Stability

No stability check was carried out on the Snare Rapids intake in the previous DSR. A stability check of the intake is required in accordance with CDA Dam Safety Guidelines Sections 2.2.3 and 9.0. The only structural information available for this DSR relating to the intake is the sketch type figures from previous reports and site observations of visible components which is insufficient to perform a complete evaluation. Although this structure has performed satisfactorily since construction; no displacement or distress was observed; the MDE is low and the proportions such as base width to height appear reasonable, a structural stability review is recommended to comply with CDA guidelines.

### 6.3.6 Summary

Despite the high water level limiting the extent of inspection of the substructure, the Intake structure and associated mechanical and electrical equipment generally appear in satisfactory condition, but some cracks require repair.

## 6.4 Power Tunnel

### 6.4.1 General

The power tunnel is a square cross section 5 m x 5 m, unlined rock tunnel about 30 m long between the downstream end of the concrete intake structure and the upstream end of the steel liner. The steel liner of the penstock, which is of riveted construction, is 4.14 m in diameter and extends about 10 m upstream of the upstream wall of the powerhouse. The steel liner is embedded in concrete within the rock tunnel portion. The power tunnel has a maximum net head of 19.95 m between MOL (EL. 222.5 m) and tailwater level (EL. 202.55) (BGC, 2005).

Another unlined tunnel, 1.8 m x 1.2 m, located in rock, runs parallel to the power tunnel and feeds the Unit 2 generator. The so called “exciter” tunnel entrance is on the left side of the Intake and turns 90° to parallel the power tunnel with a centreline spacing of about 10 m. The entrance to the exciter tunnel is located upstream of the power tunnel intake gate. It remains pressurized with reservoir water whenever the main power tunnel is drained for inspection (BGC, 2005).

Seepage from the central portion of the main dam and the power tunnel are monitored in weirs located in sumps at the left (Photo 7) and right (Photo 8) side of the upstream face of the powerhouse respectively.

### 6.4.2 Operational Performance

No direct operating problems have been reported relating to the power tunnel or penstock, and inspections by others in 1998 (Acres, 1998) and again in 2005 (BGC, 2005) indicate that the rock of the power tunnel is generally in good to excellent condition with no evidence of rockfalls or other visible instabilities. However, powerhouse maintenance (wet floors and other related maintenance issues) associated with leakage from the power tunnel through rock fissures have plagued the plant since commissioning, resulting in two previous grouting programs being carried out (one from the surface immediately after commissioning and another in 1999 from within the power tunnel itself) to reduce the amounts of leakage. The latter was initiated by NTPC as a result of concerns raised in the 1998 dam safety inspection (Acres, 1998) relating to the potential for hydraulic jacking around the power tunnel. Although the 1999 void grouting program was successful in reducing the flows from the drains around the upstream foundation of the powerhouse, it does not address the hydraulic jacking concern and the recommended program of site investigations, analysis and instrumentation to understand the potential for hydraulic jacking around the tunnel has to date not been implemented.

### 6.4.3 Current Condition

The power tunnel was not accessible during the current DSR site inspection on 12 July 2006. The inspection by others, carried out 10 months earlier (BGC, 2005), is therefore considered to be representative of existing conditions.

The 2005 inspection noted similar conditions to those reported during the previous investigation in 1998 (Acres, 1998) with the most prevalent observation still being a significant inflow of water from a sub-horizontal joint along the intersection of the crown and left side wall about 10 m upstream from the end of the steel liner. Other less dominant seepage features were also observed, all of which occur on the left side wall of the tunnel, possibly suggesting that the water bearing fractures in the power tunnel are hydraulically connected to the exciter tunnel which cannot be dewatered. At the time of the 2005 tunnel inspection the flow from the drains collecting power tunnel leakage was about 70 L/min. The same flow was observed in the sump during the 2006 DSR inspection. This flow is essentially unchanged from measurements following the successful 1999 grouting program.

The concerns raised in the 1998 dam safety inspection (Acres, 1998) and again in 2005 stemming from the observations within the dewatered power tunnel have not been adequately addressed.

Foundation and dam stability concerns as well as the potential for uncontrolled leakage of water from the tunnel and the subsequent potential for eroding overlying dam core and/or filter materials, all relating to the high capacity water bearing feature observed in the power tunnel, need to be thoroughly investigated, analyzed and understood.

It is therefore recommended that the investigation and analysis program recommended by BGC (BGC, 2005) be implemented during the next annual plant shutdown.

To date, no inspection of the adjacent exciter tunnel has been carried and it is our understanding that it is not possible to dewater this tunnel. It is therefore recommended that an inspection using a remotely operated vehicle (ROV) be considered in conjunction with the recommended power tunnel program of work, in order to determine if any structurally important geological features can be identified in the exposed rock surface of the tunnel. This would be considered more due diligence rather than a precise data gathering exercise due to the difficulties involved with precise mapping using an ROV.

### 6.4.4 Instrumentation and Monitoring

Leakage from the power tunnel has been measured in the sump located along the right side of the upstream face of the powerhouse since the void grouting program in 1999. Figure 6-6 charts the monthly readings presented in Appendix IV.

Figure 6-6 illustrates the reduction and stabilization in flow following the 1999 grouting program. Inflows generally vary with reservoir level and are typically in the order of 50 L/min to 70 L/min during lower reservoir levels, peaking between 100 and 125 L/min during high reservoir periods. The magnitudes of flows are fairly consistent with no increasing trends which would be indicative of foundation deterioration (piping) of the water bearing feature or decreasing trends which may indicate clogging of the drains along the upstream side of the powerhouse. Monitoring of seepage from the power tunnel should continue on the present schedule.

### 6.4.5 Summary

The rock of the power tunnel is generally in good to excellent condition with no evidence of rockfalls or other visible instabilities. The steel liner is also in good condition with some minor pitting and corrosion evident (Agra Monenco, 2000). Although the seepage into the powerhouse along the upstream wall remains a concern to NTPC due to wet floors and other related maintenance issues, it is the potential stability and dam safety related issues which are of more immediate concern. Currently, the implications of the water bearing features are not thoroughly understood with respect to dam safety and potential failure. It is therefore recommended that the program of further investigation, instrumentation and analysis described in the BGC memorandum (2005) be implemented as a priority.

## 6.5 Powerhouse

The powerhouse, located at the toe of the dam, is comprised of a reinforced concrete substructure up to the main (generator) floor; a braced structural steel frame superstructure; and masonry concrete block masonry walls above grade level.

The powerhouse is not considered to be dam safety related and was therefore not thoroughly inspected. Any operational and maintenance issues observed during the facility visit will be transmitted separately to NTPC.

## 6.6 Spillway 5B

### 6.6.1 General

Spillway 5B is located at the end of an arm off the southern end of Big Spruce Reservoir. The spillway is a stoplog controlled reinforced concrete structure comprising six bays each 6 m (wide) x 2.5 m (deep) and two bays each 6 m x 5.8 m, as shown on Figure 6-7 and Photo 9, and is founded on fresh, widely jointed diorite and granite of good to excellent quality. Along the upstream right side, a structurally independent retaining wall leads upstream from the right abutment and retains the fill from Side Dam 5B (Photo 10). Along the downstream right side, a timber crib retaining wall retains these same fills and supports an enclosure (Photo 11).

Water released from Spillway 5B returns to the Snare River via a 13 km long waterway, including two small lakes, rejoining the main channel 7.5 km downstream of Snare Rapids G.S. and 8 km above Snare Falls G.S. Access to the site is via boat during the summer, skidoo during winter or helicopter as appropriate.

Stoplogs are lifted by an electrically powered gantry crane, with power supplied via a 6.9 kV tie line from the Snare Rapids G.S. Back-up power is via a gasoline powered generator.

The total capacity of the spillway with reservoir level at the top of the new core EL. 223.0 m is 587 $m^3/s$ (based on the spillway rating curve confirmed in the 2000 DSR), significantly greater than the estimated 1,000 year AEP spillway design flood (routed IDF) of 457 $m^3/s$.

### 6.6.2 Operational Performance

The spillway can only be operated locally and equipment has generally performed satisfactorily. Most of the logs are removed and reinstalled during each year's normal operating cycle. A log replacement program is underway. Bad weather could present access problems and operations could be delayed.

### 6.6.3 Instrumentation and Monitoring

There is no instrumentation specific to the spillway.

### 6.6.4 Concrete Structure - Current Condition

Spillway 5B was inspected on 12 July 2006. The water level in the Big Spruce Reservoir was at EL. 221.96 m (EL. 728.20 ft), and only spillway Bay 3 was open releasing 142 $m^3/s$ (5,000 cfs). The remaining bays were closed with timber stoplogs. The high water level and discharging spillway limited inspections of the upstream and downstream sides of the spillway respectively.

The rock channel downstream of the spillway is in good condition with only minimal evidence of any bedrock erosion and no signs of any deterioration since the previous DSR. Undercutting at the downstream end of the piers between Bays 3 through 5 at the concrete/rock contact due to erosion has previously been reported (Agra Monenco, 2000). This undercutting was only observed at the Bay 3 location (Photo 12) due to spillway discharges. Although there has been no discernable deterioration since the previous inspection (based on comparison of photographs), KCBL recommends that this undercutting be repaired during the repair of the cracks adjacent to the gains at Bay 3 and Bay 4 discussed below.

A similar condition is evident at other pier locations (Photo 13), but conditions are presently not considered severe enough to warrant repair. Conditions should be monitored periodically for signs of accelerated deterioration. Any established vegetation in these locations should be removed when brushing of Side Dam 5B next takes place to prevent vegetation obscuring any deterioration of the rock/concrete contact at these locations.

The 2000 DSR report described the structural aspects of the spillway as generally in good condition with some minor cracking and spalling evident. The report did, however, describe cracks in the second stage concrete around the heated gains (steel embeds forming stoplog guides) in spillway Bay 3 and 4 which are the only bays with heated gains. The report recommended the concrete around the gains should be repaired which has not been done. The cracking has deteriorated and is now significant and it appears that the concrete between the cracks and the gains has the potential to spall off in long vertical strips (Photo 14). If this happens, the gains might twist under stoplog loading, potentially jamming a stoplog and thus inhibit or prevent stoplog removal. This deficiency is considered a dam safety concern and requires repair as soon as possible. A professional engineer experienced in the design and repair of spillway structures should undertake the design of the repair.

A 1 cm bulge and corresponding tear was observed in the left side steel embed (stoplog guide) of spillway Bay 4, approximately 2 m below deck level (Photo 15). This condition can potentially prevent stoplog sealing and possibly cause stoplog jamming and thus inhibit or prevent stoplog removal. This deficiency is considered a potential dam safety concern and requires repair as soon as possible.

The cracks in the spillway deck expansion joints recommended for monitoring in the previous DSR have deteriorated and are currently considered significant, particularly in the narrow concrete strip between the main deck slab and the gains. Some repairs have been carried out in the past, but they too have deteriorated. Although not considered a dam safety issue at present, consideration should be given to repairing the major deck cracks during the repairs of the cracks adjacent to the gains at spillway Bay 3 and 4.

The timber crib retaining wall forming the right abutment immediately downstream of the spillway (Photo 11) is in satisfactory condition and shows little change from the condition identified during the last DSR. No maintenance is required at this time.

The reinforced concrete retaining wall leading upstream from the right abutment and which retains the fills from Side Dam 5B (Photo 10) has several vertical cracks which should be monitored.

### 6.6.5 Electrical and Mechanical Equipment

The stoplog lifter is a standard twin spear unit (by William Kennedy) and is typical of older log lifters in use across Canada. It is in good condition and is reported to be reliable in all weather.

The primary power supply is from a 6.9 kV pole line from Snare Rapids, and there is a gas generator as backup. The log lifter has a 25 HP lifting motor and a 3 HP traversing motor. Operation of both electric motors and the backup gas engine were observed during the site visit.

A log book and the operating instructions were located in the lifter cabin. No operating problems were reported.

### 6.6.6 Stability

The previous DSR evaluated the stability of Spillway 5B. Extreme loading condition associated with the MDE was not evaluated because Snare Rapids was considered to be located in a zone of low seismicity - Zone 0, from the NBCC (1995) which effects were likely to be negligible and not effect design.

Given that NBCC (2005) and GSC now assign a peak ground acceleration (PGA) to the site and our current assessment of the MDE (1,000 yr AEP earthquake) is greater than the likely 475 yr AEP event previously used as the basis for not evaluating the seismic load case, a stability assessment of the Spillway 5B is required in accordance with CDA Dam Safety Guidelines Sections 2.2.3 and 9.0.

The only structural information of Spillway 5B available for this DSR are the sketch type figures from previous reports and site observations of visible components which is insufficient to perform the analysis. Although this structure has performed satisfactorily since construction; no displacement or distress was observed; the MDE is low and the proportions such as base width to height appear reasonable, a structural stability review is required for compliance.

### 6.6.7 Summary

The observed portions of the spillway structures are in generally satisfactory condition.

The following remedial measures are required:

- The cracked concrete adjacent to the gains at Bays 3 and 4 must be removed and replaced.
- The bulge in the steel embed of the stoplog guide at Bay 4 left side must be repaired.
- The undercut downstream ends of the piers at Bays 3 to 5 should be infilled with concrete.

## 6.7 Side Dam 5B

### 6.7.1 General

Side Dam 5B is a 110 m long earth/rockfill dam which closes a topographic low immediately adjacent to Spillway 5B. It is constructed on a bedrock foundation with a central till core, sand/gravel filters and wide downstream rockfill berm as shown on

Figure 6-7. The dam has a crest width of 4.57 m and upstream and downstream slopes of 1V:2.5H. Head across the dam is low, in the order of 2.0 m.

### 6.7.2 Operational Performance

Previous inspections have identified no performance problems other than a zone at the downstream toe about 50 m from the spillway where seepage exits immediately downstream of the rockfill berm, which has existed since construction. A measuring weir was constructed at the downstream seepage area in 1999, to quantify the seepage (Photo 16).

### 6.7.3 Instrumentation and Monitoring

Leakage from the toe of Side Dam 5B is measured every 3 months at the collection weir located downstream of the toe since its construction in 1999. Figure 6-8 charts the monthly readings presented in Appendix IV.

From this chart, measured weir flows have ranged from 120 to 210 L/min which correlates remarkably well with qualitative visual estimates of seepage made in previous DSRs, prior to weir construction, ranging from about 100 L/min to 225 L/min.

Also from Figure 6-8, there appears to be a general correlation of higher seepage with higher reservoir levels, however the precise trend is somewhat masked by the fact that the weir fails to collect all flows, notably during periods of higher leakage, where some flow bypass is witnessed along the left side of the structure (Photo 17). This makes it particularly difficult to determine whether the flows during times of higher seepage are actually trending upward, indicative of a deteriorating situation.

It is therefore recommended that the measuring weir structure be properly extended so that all seepage is collected and measured to allow a proper trend with reservoir level to be established. In this respect it is recommended that the current frequency of readings (every 3 months) be maintained until such time that an increasing trend can be confidently dismissed.

### 6.7.4 Current Condition

Side Dam 5B crest and slopes are overgrown with heavy brush (Photo 18) making visual assessment very difficult. This brush must be removed to allow a thorough visual inspection in the future and to minimize the risk that a potential problem is not identified in a timely manner.

From what could be observed there are no signs of developing problems or deterioration. The crest of the dam appears planar, except near the right abutment where the crest appears to drop by about 0.6 m (2 ft) over a 20 to 30 m distance (Photo 19). This is consistent with the information on the available drawings which indicates that the crest level varies between EL. 224.94 m (EL. 738.0 ft) to EL. 225.55 m (EL. 740.0 ft). It is recommended that a crest survey be undertaken following vegetation clearing to more accurately determine the crest profile.

The rockfill on the upstream face of the dam is patchy in places (Photo 20) with a lack of some larger sizes in areas, but generally show no evidence of instability or erosion. Greater consistency in gradation and size was observed towards the right abutment. Considering the limited fetch, wind setup and wave run-up effects are likely to be minimal and so the rockfill is considered acceptable in its current condition, but warrants monitoring for possible signs of deterioration. Accumulations of woody debris on the upstream face should be removed at the same time brushing of the embankment is undertaken to prevent initiating deterioration of the upstream rockfill.

Access to the toe berm was extremely limited due to the presence of heavy brush and visual observation of its physical condition was completely obscured. Clear seepage was witnessed emanating directly from the dam toe with no signs of deterioration or distress. The seepage is not considered a dam safety concern in view of the low head across the embankment, and conservative dam design.

### 6.7.5 Stability

The stability of the dam was not checked during the 2000 DSR but was considered to be conservatively designed. No stability issues are identified.

### 6.7.6 Summary

The measuring weir structure at Side Dam 5B must be properly extended so that all seepage is collected and measured. The frequency of current weir measurements should be maintained.

Side Dam 5B is generally overgrown with well established, heavy brush, which must be removed from the crest and slopes of the dam to allow the opportunity for meaningful inspection. Accumulations of woody debris on the upstream face should also be removed.

## 6.8 Side Dam 4

### 6.8.1 General

Side Dam 4, which is located approximately 1 km northeast of Spillway 5B (see Figure 1-2), has a maximum height of about 8 m and a crest length in the order of 130 m. The dam was raised in 1960 to accommodate a higher reservoir level and has an impervious central core of compacted silt with top at EL. 224.4 m (EL. 736.0 ft) and sand and gravel shells with a downstream rockfill berm as illustrated on Figure 6-7. The upstream and downstream shells are sloped at 1V:2.5H. Freeboard at maximum operating level of EL. 222.3 m (EL. 729.3 ft) is 2.95 m to the design crest of the dam and 2.04 m to the top of the core.

### 6.8.2 Operational Performance

Previous inspections have identified no safety concerns or operational difficulties. The previous DSR concluded the dam to be in good condition with no visible signs of instability or other signs of developing performance problems and no re-occurrence of the minor longitudinal cracking on the downstream berm identified in the 1987 and 1994 inspections.

Additional rockfill was recommended to be placed along the downstream berm as a precaution against lateral spreading due to permafrost thaw in the 1998 Dam Safety Report and 1999 inspection (DIAND, 1999). Subsequent inspections did not recommend this remedial measure and it has thus not been implemented.

### 6.8.3 Instrumentation and Monitoring

There is no instrumentation specific to Side Dam 4.

### 6.8.4 Current Condition

Side Dam 4 appears visually to be in a generally satisfactory condition. The crest has some minor undulations but generally appears planar with no visible settled areas (Photo 21), although there are some localized and isolated instances of minor erosion and gullying and the crest shoulders have become slightly rounded (Photo 22). No action except for annual monitoring for signs of accelerating deterioration is warranted in this regard. Larger sized vegetation is becoming established on the crest which is beginning to impede inspection and assessment and should be removed before it becomes problematic from both an inspection and performance stand point.

Riprap on the upstream face of the dam is variable in size with areas noticeably deficient of the average 1 m diameter sizes reported to be present in the 2000 DSR and which is visible within the rockfill bund mounded 1m above the top of the slope. Towards the left abutment there are signs of erosion and beaching (Photo 23). This is less evident toward the right abutment. Based on the descriptions in the previous DSR, the riprap on the upstream face has deteriorated and the current observed conditions warrant remedial attention to prevent further deterioration. Areas of missing and deficient riprap should be replaced with material in accordance with the original design. Vegetation becoming established on the upstream slope and woody debris accumulations (Photo 24) should also be removed.

The downstream slope is typically planar with some localized areas of erosion and rutting in the sand/gravel fills due to surface runoff which should be monitored during the annual inspection. Vegetation established on the downstream face impedes inspection and assessment and should be removed during next brushing.

Inspection of the downstream toe revealed a localized area of stagnant water, but no visible or audible signs of concentrated seepage were identified. There are no signs of instability or significant sloughing of the downstream slope or berm (Photo 25). The minor longitudinal cracking noted on the downstream berm in the 1987 and 1994 inspections were not discernable during the 2006 inspection, possibly indicating that any lateral spreading as a result of permafrost thaw has stabilized. The current observed conditions do not justify additional buttressing (rockfill berm) as recommended in previous investigations, however vigilant inspections of the area must be maintained by NTPC staff for any signs of changing conditions.

### 6.8.5 Stability

The stability of the dam was not checked during the 2000 DSR. No stability issues have been identified.

### 6.8.6 Summary

Riprap on the upstream face of the dam is deficient in places and must be replaced. Side Dam 4 is generally overgrown with well established, heavy brush, which must be removed from the crest and slopes of the dam to permit meaningful inspection. Accumulations of woody debris on the upstream face should also be removed.

## 6.9 Side Dam 9B

### 6.9.1 General

Side dam 9B was constructed in 1960 to contain the reservoir when the MOL was initially raised from EL. 219.46 m (EL. 725 ft) to EL. 221.0 m (EL. 725 ft). It is located about 3 km northeast of the Snare Rapids G.S. as shown in Figure 1-2. The dam is a sand fill embankment with upstream clay blanket, with a crest length of approximately 60 m and height of 3 m as illustrated on Figure 6-7 and shown on Photo 26. Note that the available drawing (see Figure 6-7) does not illustrate the upstream clay blanket reported previously (Agra Monenco, 2000). The upstream and downstream shells are sloped at 1V:3H. It is founded on permafrost muskeg, with bedrock abutments.

### 6.9.2 Operational Performance

The dam has been topped-up several times since construction due to settlement resulting from permafrost thaw, most recently in 1992. The last DSR concluded that slopes were stable with no signs of instability and no significant crest settlements existed with freeboard assessed to be in the order 2 m at MOL. Foundation permafrost thaw was considered to have stabilized.

### 6.9.3 Instrumentation and Monitoring

There is no instrumentation specific to Side Dam 9B.

### 6.9.4 Current Condition

At the time of inspection (reservoir at El. 728.20 ft) there was approximately 1.5 m (5 ft) of head across the dam. The crest of the dam appears to have undergone some additional settlement, no greater than about 0.25 m, based on visual assessments (Photo 27). A crest survey is recommended to confirm this observation and provide a quantitative baseline for future inspections with ongoing monitoring required to ensure settlement does not go undetected.

The upstream slope of the dam shows some signs of minor rutting in areas due to surface run-off eroding the relatively loose sand fill, but not significant or prevalent over extensive areas (Photo 28). The slopes are stable and there are no signs of developing instability. Although the embankment is relatively protected from significant wave action due to the dam's location at the end of a long narrow inlet, KCBL concurs with the previous DSR recommendation to place 30 cm of fine rockfill or crushed gravel on the upstream face to prevent erosion from wave action and from surface runoff and to limit the potential for maintenance work in the future. There is a large raft of woody debris (about 10 m deep) accumulating in the cove at the upstream face (Photo 29) which should be removed before it becomes deposited on the sandy face of the dam and causes deterioration.

The downstream slope is in a satisfactory condition, appears stable, is free of any significant erosion or rutting and exhibits no visible abnormalities or signs of developing performance problems (Photo 30). Ponded water exists in the muskeg downstream of the dam, which was also observed during the previous inspection. There are no visible or audible signs of concentrated seepage and no boils were identified.

### 6.9.5 Summary

Overall the dam is in satisfactory condition. Some crest settlement appears to have taken place since the last DSR and a crest survey is recommended to confirm the visual assessment. A large mat of woody debris has accumulated in the water body immediately in front of the dam which should be removed.

# 7. SNARE FALLS

## 7.1 General

The Snare Falls Generating Station (G.S.) is located 15.5 km downstream of Snare Rapids G.S. on the Snare (see Figure 1-2) and was commissioned in 1960. The development consists of an earth / rockfill main dam with crest at EL. 205.74 m (EL. 675.0 ft), approach channel on the right abutment of the main dam, spillway, intake structure, and powerhouse with a single 7.8 MW Kaplan unit as illustrated on Figure 7-1. Reservoir MOL is at EL. 202.4 m (EL. 664.0 ft) resulting in a net head of 19.8 m. Snare Falls is the only plant with a gated spillway which is operated to balance inflow and outflow as determined from observation of forebay reservoir levels. According to the OMS manual and site staff, the spillway gates are only operated occasionally. Two right bank saddle dams close topographic lows on the right bank within 1 km of the main structures. Layout and typical sections are included in Figure 7-2.

The Snare Falls G.S. was inspected on 13 July 2006 when the reservoir was at EL. 202.27 m (EL. 663.61 ft). Spillway gate 1 was open 0.9 m (3 ft) and spillway gate 2 was open 1.4 m (4.5 ft). The weather was sunny and warm.

## 7.2 Main Dam

### 7.2.1 General

The main dam is a zoned earth/rockfill embankment founded on bedrock with crest length of 152 m and maximum height of 23 m. The dam has a central core of rolled silt with sand and gravel filters and rockfill shells as illustrated in cross section on Figure 7-2. The design top of the core is at EL. 204.82 (EL. 672.0 ft) with 0.9 m of granular frost protection. The upstream shell is generally sloped at 1V:2.5H with a 1.3 m (4 ft) riprap wave breaker along the upstream crest providing additional wave run –up protection and for future maintenance. The downstream shell is sloped at 1V:2H.

### 7.2.2 Operational Performance

Previous dam safety inspections have identified no concerns with the main dam. Drilling undertaken as part of the previous DSR indicated that post-construction settlements have been minor and the top of the core is still well above MOL of EL. 202.4 m (EL. 664.0 ft).

### 7.2.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Falls main dam.

### 7.2.4 Current Condition

The crest of the dam appears planar with no visible cracking, settled areas, erosion or abnormalities (Photo 31). At the west end where the dam alignment makes a sharp 90 degree turn, there is some minor tire rutting from vehicular traffic which currently does not effect performance. Brush is becoming established along the crest shoulders and should be removed as part of regular maintenance while it is still small enough to do so easily (Photo 31).

The rockfill upstream shell is in good condition with no beaching or erosion damage (Photo 32). Visible rock on the upstream face is well graded from cobble sizes to about 0.6 m diameter particles and shows no sign of breakdown or deterioration. Removal of brush from the upstream face (Photo 32) is recommended to facilitate performance monitoring. Minor accumulations of woody debris should also be removed from the upstream face when brushing of the slope takes place.

The downstream shell of the dam is planar with no settled areas, erosion gulleys or visible seepage along the abutment contacts or toe (Photo 33).

Minor seepage is observed in the rock face behind the powerhouse along a sub-vertical shear zone in the rock abutment from the intake channel.

### 7.2.5 Stability

The stability of the main dam was assessed in the previous DSR where it was concluded that stability under normal service and extreme loading conditions would exceed current CDA guidelines and USBR/USACE design criteria by a considerable margin.

There has been no new information, since the previous assessment that would require a re-evaluation of the dam stability. Although our current assessment of the MDE (1,000 year AEP earthquake) may possibly be considered a changed load condition (it is not clear what AEP earthquake was considered in the previous stability assessment, but is suspected to be the 475 year event from the NBC (NRC, 1995)). An earthquake with peak ground acceleration of 0.035 g is not likely to govern the design of a rockfill dam with slopes of 1V:2H. Stability of the main dam under normal service and extreme loading conditions is considered acceptable by inspection.

### 7.2.6 Summary

The main dam is in good condition with no areas requiring maintenance other than removal of brush from the crest and upstream shell.

## 7.3 Spillway

### 7.3.1 General

The spillway headworks consist of a concrete structure founded on bedrock supporting two gates separated by a 2.4 m wide pier with the sill at EL. 195.38 m. (EL. 641.0 ft). The left bay has heated gains (steel embeds forming gate guides). The spillway includes a steel frame superstructure for gate and stoplog operation (Photo 34).

On the right side there is a 14 m long auxiliary overflow weir with crest at EL. 202.4 m (EL. 664 ft), sized to discharge the maximum plant flow in the event of a sudden plant shutdown (Photo 35).

The capacity of the gated spillway is approximately 580 $m^3/s$ with the forebay level at the top of the main dam core, EL. 204.82 m (EL. 671.9 ft), based on the spillway rating curve confirmed in the 2000 DSR, which is significantly greater than the estimated 1,000 year AEP spillway design flood (routed IDF) of 457 $m^3/s$.

### 7.3.2 Operational Performance

The previous DSR (AGRA Monenco, 2000) concluded that the spillway was in good condition with sound concrete (based on Schmidt hammer tests) and no remedial measures were required at that time. Several cracks were identified in the spillway chute slab, indicative of the onset of weathering, and larger cracks observed on the downstream end of both piers. The cracks were concluded not to be indicative of any distress.

There have been no reported operational difficulties with the Snare Forks spillway.

### 7.3.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Falls spillway.

### 7.3.4 Current Condition

Water level was high (EL. 184.56 m) which limited the inspection of the upstream portion of the concrete structure and spillway discharges prevented observation of the spillway chute slab.

The diagonal cracks which were noted on the downstream end of both abutment piers during the previous inspection are still evident (Photo 36) but are considered to be unchanged (based on descriptions). While the observed cracks are significant, the concrete each side of the cracks appears to be supported on bedrock and there are no other physical indications of structural distress and therefore only ongoing monitoring is recommended at present.

Several long vertical cracks were observed adjacent to all the gate guides but particularly the heated ones for the left gate (Photo 37). The pattern is similar to, but not as severe as, the cracks observed at Snare Rapids Spillway 5B Bays 3 and 4 which also contain heated guides. These vertical cracks at the Snare Falls Spillway adjacent to the guides require monitoring.

### 7.3.5 Electrical and Mechanical Equipment

The main spillway has two screw stem gates 5.8 m (w) x 7.0 m (h). The hoists are in an insulated house on top of a steel structure (Photo 34). One gate is heated for winter operation and can be kept free of ice. The other becomes embedded in ice and is inoperable during the winter. Stoplogs are also provided, which can be installed upstream of either gate to facilitate inspection and repairs (Photo 38). Detailed operating instructions and precautions are contained in the OMS manual. Spillway gate operation is performed from the control panel at road level and is by manual pushbutton (Photo 39). Each gate hoist has a backup gas engine in the event of problems with the electric hoist motors.

Inspection of the gates was limited to observations made from the spillway deck. From this vantage point, there appeared to be no visible change in condition from the previous assessment. The recommendations from the previous DSR to carry out ultrasonic thickness testing on the gate skin plates has reportedly not been carried out and there is no documentation and no information from site staff on this work. The OMS manual also identifies problems with the control system and the electric power supply. Some of the limit switches are reported to be dysfunctional and the backup gas engine is only usable during the winter if there is still electric power to the gate heaters. Power supply is from the rural distribution system, and as long as power is being generated by one of the stations, the heating system should remain on.

The Snare Falls station service backup diesel is reported to be not functioning and may be removed. The plant and the spillway will rely on the electric supply from the other stations. These spillway gates can not be operated in winter if there is a power failure to the heating system for enough time to freeze. A reliable electric supply system consisting of redundant supply sources is critical to complying with dam safety requirements for flow control equipment.

NTPC staff advised that the spillway gates are normally operated one at a time as one gate appears to have sufficient capacity to pass any excess flows that have been encountered to date.

### 7.3.6 Stability

No stability check was carried out on the Snare Falls spillway in the previous DSR. A stability check of the spillway is required in accordance with CDA Dam Safety Guidelines Sections 2.2.3 and 9.0. The only structural information available for this DSR relating to the spillway is the sketch type figures from previous reports and site observations of visible components which is insufficient to perform a complete evaluation. Although this structure has performed satisfactorily since construction; no displacement or distress was observed; the MDE is low and the proportions such as base width to height appear reasonable, a structural stability review is recommended to comply with CDA guidelines.

### 7.3.7 Summary

The concrete spillway and overflow weir structures and associated steel superstructure are basically in a sound condition but some cracks require monitoring as part of ongoing annual inspections and maintenance.

It is recommended that the second spillway gate be made suitable for winter operation and that the deficiencies noted in the OMS manual be rectified.

## 7.4 Intake

### 7.4.1 General

The concrete intake structure is founded on bedrock adjacent to the spillway. The intake consists of two bays: one currently supplying the powerhouse and one constructed in advance for a possible "future expansion" (considered unlikely due to insufficient water supply). The intake includes a steel frame superstructure for gate and stoplog operation (Photo 40).

### 7.4.2 Operational Performance

The 2000 Report concluded that the intake concrete substructure and steel superstructure were in good condition and no remedial measures were required. There have been no reported operational difficulties with the Snare Forks intake.

### 7.4.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Falls intake.

### 7.4.4 Current Condition

Although the water level was high during the current inspection which limited the substructure observations, the intake appears to be in a satisfactory condition and no remedial measures are required.

### 7.4.5 Electrical and Mechanical Equipment

The intake gate is a 4.27 m x 4.88 m (14 ft x 16 ft) wheeled gate operated by an elevated wire rope hoist in an insulated hoist house (Photo 41). Power supply to the hoist and gate heaters is from the powerhouse station service system. The intake gate was not able to be directly inspected as it was under water and the unit was operating. The gate was reported to be in good condition with no operating problems. The thickness measurements of the gate steel recommended in the 2000 inspection to check for corrosion or material loss have not been carried out.

The gate hoist assembly, stoplogs and stoplog hoist appeared to be in good condition. Plant staff advised that the gate is regularly tested for emergency closure from both remote and local controls. Maintenance records and test results are kept in the NTPC

Engineering office in Yellowknife. No test records were available at site and none have been made available for review.

### 7.4.6 Stability

No stability check was carried out on the Snare Falls intake in the previous DSR. A stability check of the intake is required in accordance with CDA Dam Safety Guidelines Sections 2.2.3 and 9.0. The only structural information available for this DSR relating to the intake is the sketch type figures from previous reports and site observations of visible components which is insufficient to perform a complete evaluation. Although this structure has performed satisfactorily since construction; no displacement or distress was observed; the MDE is low and the proportions such as base width to height appear reasonable, a structural stability review is recommended to comply with CDA guidelines.

### 7.4.7 Summary

The concrete intake structure and associated steel superstructure are in sound condition. High water level limited the inspection of the upstream side of the intake.

The intake gate was reported to be in good condition with no operating problems. The gate hoist assembly, stoplogs and stoplog hoist appear to be in satisfactory condition.

Stability analyses for the spillway and intake must be undertaken to comply with CDA guidelines.

## 7.5 Power Tunnel

The power tunnel is excavated in rock and is lined with a 4.27 m (14 ft) inside diameter steel penstock for 30 m upstream of the powerhouse. The power tunnel was not dewatered for the 2006 inspection and there have been to date no inspections of this particular feature. Although not considered a dam safety issue the power tunnel should be dewatered and inspected prior to or during the next dam safety inspection.

## 7.6 Powerhouse

The powerhouse is located at the toe of the main dam and comprises a reinforced concrete substructure up to the main (generator) floor; a braced structural steel frame superstructure; a concrete wall on the upstream side; and steel sheet cladding above grade level at the other three sides (Photo 42).

The powerhouse is not considered to be dam safety related and was therefore not thoroughly inspected. Any operational and maintenance issues observed during the facility visit will be transmitted separately to NTPC.

## 7.7 Saddle Dam No.1

Saddle Dam No. 1 is a zoned earthfill dam with a current nominal crest level which is 1.24 m (4 ft) below the current crest of the main dam. The dam is approximately 100 m long with a maximum height of 2.6 m (8.5 ft). The dam was lowered from its previous crest level at EL. 207.2 m (EL. 680.0 ft) to EL. 204.5 m (EL. 670.9 ft) in 2003 as an improvement measure in order to act as a secondary (fuse plug) spillway in the event that emergency flood handling is required at Snare Falls. The new profile and typical cross section are shown on Figure 7-3. The saddle dam has a central core of rolled silt and shells of sand with rockfill erosion protection upstream and downstream. Head across the Saddle Dam No. 1 is minor – in the order of 1.0 m at normal operating level.

As shown on Figure 7-3, the excavation to lower the dam has left it with a generally variable crest profile but which is typically lower near the left abutment. Considering the intended function to act as a fuse plug type spillway rather than as a saddle dam, this is not considered to be of concern.

Inspection showed the dam/fuse plug to be in good condition. The upstream and downstream shells show no settled areas, erosion or evidence of instability and the downstream toes are dry with no evidence of seepage. Although the crest of the dam is clear of vegetation due to the recent construction activities, removal of vegetation from the upstream face (Photo 44) is recommended to facilitate future performance monitoring.

## 7.8 Saddle Dam No.2

Saddle Dam No. 2 is a zoned earthfill dam with a crest length of about 90 m and maximum height of 8 m which closes a narrow topographic low west of Saddle Dam No.1. The saddle dam is on a soils foundation and has a central core of rolled silt and shells of sand with rockfill erosion protection upstream and downstream. The saddle dam has a design crest elevation of EL. 207.26 m (EL. 675.0 ft), 1.52 m (5 ft) above the crest of the main dam. Head across the Saddle Dam No. 2 is minor – in the order of 1.0 m at normal operating level. No safety concerns or performance problems have been identified in previous dam safety or annual inspection reports with regards this structure.

Access, walkover and observation were hampered by heavy brush and small trees which are well established on the crest and slopes of the dam (Photo 45). Based on limited sight distances the dam generally appears to be in satisfactory condition. The upstream and downstream shells show no settled areas or evidence of instability and the downstream toe was dry, with no seepage or ponded water. There is no evidence of crest settlement, but the discontinuous longitudinal depressions occurring near the upstream and downstream sides of the crest which have been identified in previous reports were still evident (Photo 46) and based on comparisons with previous photographs remain inactive.

No remedial work is recommended except for the removal of the brush and saplings from the crest and shells of the saddle dam to facilitate future performance monitoring.

# 8. SNARE CASCADES

## 8.1 General

The Snare Cascades Development was commissioned in 1996 and is owned by the Dogrib Power Corporation and operated by NTPC. The development is located 3 km downstream of Snare Falls (see Figure 1-2) on the Snare River and is a run-of-river facility.

The overall development (see Figure 8-1) consists of a concrete labyrinth spillway with a crest level at EL. 182.88 m (EL. 600 ft), an approach channel and a powerhouse equipped with an “S” type turbine designed to generate 4.3 MW with a rated gross head of 9.15 m as shown on Figure 8-2. The current licensed operating level is EL. 182.88 m (EL. 600 ft) with the unit operating. When the unit is off line, or discharges from the upstream plants are greater than the design capacity of the unit, the flows pass over the top of the labyrinth spillway.

Snare Cascades facilities were inspected on 14 July 2006 when the forebay level was at EL. 183.56 m (EL. 602.23 ft) overtopping the spillway by about 0.7 m and the tailwater level was at EL. 174.57 m (EL. 572.74 ft). Based on the spillway rating curve (Figure 4-1) discharge from the free-flow labyrinth spillway was approximately 126 $m^3/s$ (4,450 cfs). The weather was sunny and warm.

## 8.2 Labyrinth Spillway

### 8.2.1 General

The free-flow labyrinth concrete spillway structure is founded on bedrock. There is a double cell concrete box culvert with an upstream concrete stoplog arrangement situated below the main spillway structure adjacent to the left abutment and a lateral concrete retaining wall upstream of the left abutment as shown on Figure 8-3.

### 8.2.2 Operational Performance

The 2000 DSR concluded that there were no dam safety issues with the spillway although a thorough inspection of the spillway concrete was not possible due to overtopping.

### 8.2.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Cascades labyrinth spillway.

### 8.2.4 Current Condition

During the 2006 inspection, only the left abutment was accessed. Flow over the spillway was smooth and uniform (Photo 47) indicating no erosion and satisfactory performance and hence the spillway does not appear to have suffered any major erosion of the labyrinth wall. NTPC reported a significant crack and leak in the lower level twin box culvert adjacent to the left abutment. This condition should be inspected and documented again during the next low flow period when the culverts can be accessed to identify if any deterioration has occurred. The lateral retaining wall to the upstream of the left abutment displays minor vertical cracks which should be monitored as part of the annual inspections.

Based on the visual conditions at the time of the inspection the labyrinth spillway is in satisfactory condition.

### 8.2.5 Stability

The 2000 Report noted minor erosion of the overburden slope at the right abutment immediately downstream of the weir but above MOL. An attempt has been made to repair it with sandbags but the problem remains. KCBL concur with conclusion in the 2000 DSR that it is not a dam safety issue at present but recommend remedial measures be undertaken as part of general plant maintenance in order to provide a permanent solution.

### 8.2.6 Summary

The labyrinth concrete spillway appears in a sound condition but the high water level limited the inspection. It is recommended that the significant crack in the twin box culvert structure beneath the spillway be inspected and documented during the next low reservoir period when access is possible and remedial measures are required to permanently address the observed erosion at the right spillway abutment.

## 8.3 Power Canal Dyke

### 8.3.1 General

The power canal is contained partially in a rock cut and partially by the power canal dyke on its right side, which is constructed of rockfill supporting a vertical 0.3 m wide concrete cutoff wall, which is founded on bedrock (see Figure 8-4). The upstream face of the cutoff wall is covered with a plastic geomembrane, which is protected against damage from the rockfill by a 12 mm fibreboard layer.

### 8.3.2 Operational Performance

Previous inspections have identified no dam safety related concerns with the power canal dyke. Previous inspections noted a short section of exposed geomembrane on the upstream face of the dyke and a few small depressions in the downstream rockfill berm. The noted defects were not considered to warrant remedial action at that time.

### 8.3.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Cascades dyke.

### 8.3.4 Current Condition

Inspection of the dyke crest showed no obvious settled areas, erosion or abnormalities. The crest is typically planar (Photo 48), but narrows slightly at about mid-dyke in an area where additional rockfill has been added to cover the previously observed exposures of concrete cut-off wall (Photo 49). It is recommended that a new crest survey be completed to document the new construction and provide a benchmark for future inspections.

The upstream slope is typically planar with no signs of slumping or other indications of instability. There is a slight distortion in the slope of the fill in the area where the new rockfill was added to cover the exposed concrete cut-off wall (Photo 50). The rockfill is in good condition with no beaching or erosion damage and no sign of breakdown or deterioration. Minor accumulations of woody debris on the upstream face near the intake should be removed as part of the scheduled maintenance.

The downstream slope is planar with no signs of erosion, instability or seepage (Photo 51). Visually the downstream slope appears steeper at locations downstream of the "dog-leg" bend at about mid length along the dyke axis. The slopes appear to have been constructed in this manner. A slope survey is recommended to determine the current condition and should be carried out at the same time as the recommended crest survey.

The crest of the lower bench is typically planar with no signs of cracks, significant depressions or other signs of instability or distress (Photo 52). Near the spillway there appear to be some localized depressions in the surface (Photo 53). These areas currently do not require remedial work but must be monitored and documented during the annual inspections for signs of change. The downstream slope of the lower bench is also planar, with no signs of instability or other distress and no observable seepage exists above the river level. The rockfill protection appears sound and in good condition (Photo 54). There is a localized area on this lower slope where the rockfill appears finer ($d_{50}$ = 150-200 mm) than the typical surrounding material ($d_{50}$ = 750 mm), but there is currently no associated beaching or erosion (Photo 55). Ongoing monitoring and documentation of this area during future annual inspections is recommended.

It is recommended that the brush be removed from the lower slope as part of the next routine maintenance (Photo 55).

#### 8.3.5 Summary

The approach channel dyke is in satisfactory condition. A new crest survey is recommended to document changes since rockfill was added to repair the exposed geomembrane. Some localized areas required ongoing monitoring during future annual inspections and brush and woody debris to be removed from the slopes as part of scheduled maintenance.

### 8.4 Powerhouse and Intake

#### 8.4.1 General

The powerhouse is located at the end of the power canal and comprises a reinforced concrete substructure with high reinforced concrete walls; a braced structural steel frame superstructure commencing at the house crane rail level; and steel sheet cladding to the superstructure. The intake, including its hoist tower for the gate, is located with the powerhouse building enclosure but with a localized higher roof (Photo 56). Likewise, the draft tube gate is located within the powerhouse enclosure and the gate is handled by the house crane. The unit was operating at the time of the inspection.

#### 8.4.2 Operational Performance

No significant deficiencies of the powerhouse and intake were reported in the last DSR.

#### 8.4.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Cascades powerhouse and intake.

#### 8.4.4 Current Condition

The intake is within the powerhouse enclosure. The very limited amount of the substructure that was visible and the steel frame superstructure including the cladding appeared in sound condition (Photo 57).

The interior of the powerhouse displays multiple zones of cracks, seepage and efflorescence. The more severe zones require repair. (Photo 58)

A significant part of the powerhouse interior surfaces of the exterior walls have had a poor quality plaster layer applied, likely to cover up other defects. At some locations the plaster is spalling off, probably due to seepage through the walls. These zones require removal of the plaster layer and crack and seepage repair. These defects do not jeopardize the overall integrity of the structure but the more severe defects should be repaired.

The tailrace channel excavated in rock appears stable with no signs of erosion or other deterioration.

### 8.4.5 Electrical and Mechanical Equipment

The intake gate equipment is in very good condition and no operating or maintenance issues were observed or related by NTPC operating staff.

### 8.4.6 Summary

The powerhouse and intake are in generally satisfactory condition.

# 9. SNARE FORKS

## 9.1 General

The Snare Forks development is located 10 km downstream of Snare Cascades G.S. on the Snare River. It is the plant furthest downstream in the cascade and was commissioned in 1976 (see Figure 1-2).

The design of the plant took advantage of a natural fork around an island in the Snare River. The south arm of the channel was impounded by Strutt Lake dam just upstream of the river entrance to Strutt Lake. A powerhouse containing two vertical shaft Francis units with 9.2 MW of capacity at gross head of 14.6 m is located at the dam's toe and is connected to an intake located in the reservoir forebay via a power tunnel.

A 100 m long crescent shaped concrete weir free-flow spillway was constructed adjacent to the west channel of the fork into which it discharges. Floods are passed through a rock cut spillway channel and the original fork to Strutt Lake. The fork is closed off by a zoned earthfill dam – the Snare Forks dam. A series of three low sand fill dykes are located on the road between the Strutt Lake and Snare Forks dams. The general site arrangement is shown on Figure 9-1.

Snare Forks facilities were inspected on 13 July 2006 when the forebay level was at EL. 174.34 m (EL. 571.97 ft). The weather was sunny and warm.

## 9.2 Spillway

### 9.2.1 General

The ungated spillway is a low free overflow weir with crest level at EL. 173.74 m (EL 570.0 ft) founded on bedrock with a design capacity, based on the spillway rating curve confirmed in the 2000 DSR, of 480 $m^3/s$ at forebay level EL. 175.6 m (EL. 576.0 ft) equivalent to the top of the core in the main dams, which is greater than the estimated 1,000 year AEP spillway design flood (routed IDF) of 457 $m^3/s$.

### 9.2.2 Operational Performance

There are no known performance deficiencies relating to the spillway and NTPC staff report satisfactory past performance. No visible deficiencies of the spillway were reported during the last inspection (Agra Monenco, 2000) which was undertaken from the banks as the spillway was operating. However, the 1998 Dam Safety Inspection Report (Acres 1998) noted the concrete was in excellent condition. NTPC report that a survey of the rock cut channel downstream of the spillway was carried out in 2003, but no documentation was ever produced.

### 9.2.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Forks spillway.

### 9.2.4 Current Condition

The spillway was inspected from the banks (Photo 59). The depth of flow over the crest was approximately 0.6 m (2 ft) corresponding to a discharge in the order of 85 $m^3/s$ (3,000 cfs), precluding inspection of the structure itself.

Flow over the concrete spillway appeared smooth with no irregularity in the flow patterns indicative of crest erosion and there was no indication of erosion of the toe of the spillway. The spillway rock cut channel downstream of the control structure is in good condition (Photo 60). No maintenance work is required.

### 9.2.5 Stability

The cross sectional properties and details of the spillway were only available diagrammatically and are not sufficiently detailed to carry out a meaningful stability review. However, no stability issues are identified.

### 9.2.6 Summary

The anecdotal evidence suggests the uncontrolled concrete spillway structure is in a satisfactory condition with no significant deterioration since the previous inspection, but high water levels and spillway discharge limited the inspection. No remedial measures are recommended at this time; however it is recommended that NTPC undertake a documented inspection of the spillway when water levels next fall below the crest.

## 9.3 Snare Forks Dam

### 9.3.1 General

Snare Forks dam is a zoned earth-rockfill dam with a sloping till core, sand and gravel filters and rockfill shells. The dam has a crest length of 105 m and a maximum height of 10 m. The design crest of the dam is EL. 176.78 m (EL. 580.0 ft) with 1.2 m (4 ft) of granular fill over the top of the core. It is similar in section to Strutt Lake Dam shown on Figure 9-2.

### 9.3.2 Operational Performance

No safety concerns were identified in previous inspection reports on the Snare Forks dam. The recommendation to install a culvert through the cofferdam, with invert slightly below pond level, has been carried out (Photo 61).

### 9.3.3 Instrumentation and Monitoring

At the time of inspection, the outlet of the culvert through the cofferdam was partly submerged due to spillway release and so seepage from the pond could not be measured (Photo 62). NTPC staff however confirmed that measurements from the culvert are not taken even when the outlet is accessible at times when lower flows are discharging from the spillway. It is recommended that seepage be monitored by recording the time taken to fill a container of known volume at the culvert outlet, when conditions are favourable to do so in order to quantify seepage.

An August 2005 centreline survey (see Figure 9-3) shows the crest of Snare Forks dam varying from slightly above design grade (0.3 m) to very slightly below design grade (0.04 m).

There is no instrumentation specific to the Snare Forks dam.

### 9.3.4 Current Condition

The dam appears to be in good condition with no discernable changes from the last DSR inspection in 2000. The crest is planar, with no visible settlement, cracks or erosion gulleys (Photo 63). The upstream slope shows no signs of settled areas or instability and no erosion or beaching of the riprap (Photo 64). The riprap in a small localized area toward the right abutment is finer than elsewhere and should be monitored for erosion and beaching in future inspections. Localized replacement should be considered within the next few years to prevent larger scale deterioration, or sooner if warranted by conditions.

The downstream shell is planar with no settled areas or evidence of instability (Photo 65). There is no visible seepage from the abutments or dam toe in areas above the water level in the downstream pond. The pond itself exhibits no change from descriptions in previous reports.

### 9.3.5 Stability

The stability of Snare Forks dam was assessed in the previous DSR where it was concluded that stability under normal service and extreme loading conditions would meet current CDA guidelines and USBR/USACE design criteria.

There has been no new information since the previous assessment that would require a re-evaluation of the dyke stability. Our current assessment of the MDE (1,000 yr AEP earthquake) may possibly be considered a changed load condition (it is not clear what AEP earthquake was considered in the previous stability assessment, but is suspected to be the 475 yr event from the NBC (NRC, 1995)). An earthquake with peak ground acceleration of 0.035 g is not expected to govern the design. No stability issues are identified.

### 9.3.6 Summary

The dam is in good condition with no evidence of significant deterioration or developing performance problems. Seepage should be monitored at the culvert outlet, when conditions are favourable to do so. No remedial work is currently considered necessary.

## 9.4 Freeboard Dykes

### 9.4.1 General

Three sand fill dykes, founded on permafrost-affected lacustrine soils, form part of the road between the Snare Forks and Strutt Lake dams and dam topographic lows along the right side of the reservoir rim (see Figure 9-1). Dyke 1 is located about 0.5 km west of the Strutt Lake dam and usually has about 0.8 m of head across it at MOL. Dykes 2 and 3 are located further west and are considered to be freeboard dykes with no head against the embankments at maximum operating level.

### 9.4.2 Operational Performance

These dykes are founded on permafrost-affected lacustrine soils with significant preconstruction ice contents, and have required periodic topping up since construction due to thaw consolidation of the foundation. During previous inspections from 1987 to 1998, visible settlement and minor longitudinal cracking were evident. In 1999, 14 months prior to the 2000 DSR, the dykes were topped up again to elevations ranging from EL. 175.2 m (EL. 574.8 ft) to EL. 175.7 m (EL. 576.4 ft) but still generally below the design crest. The dykes were otherwise assessed to be in good condition.

### 9.4.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Forks freeboard dykes.

An August 2005 a centreline survey of Freeboard Dyke 1, 2 and 3 indicated:

- the crest of Freeboard Dyke 1 was 0.78 m (2.6 ft) to 2.10 m (6.9 ft)below design grade (see Figure 9-4);
- the crest of Freeboard Dyke 2 varied from 0.07 m (0.2 ft) above design grade to 1.43 m (4.7 ft) below design grade (see Figure 9-3); and
- the crest of Freeboard Dyke 3 was 0.84 m (2.8 ft) to 1.52 m (5.0 ft) below design grade (see Figure 9-3);

### 9.4.4 Freeboard Dyke 1 - Current Condition

On 15 June 2006 Freeboard Dyke 1 was breached resulting in a subsequent failure of the structure. At the time of the 2006 inspection, reconstruction was in progress (Photo 66) and the dyke was not inspected. NTPC report that the incident is being addressed in separate documentation describing the conditions leading up to the failure and subsequent repair. At the time of inspection, the dyke was therefore in an unsatisfactory condition; however the deficiency was in the progress of being addressed. It is anticipated that an appropriate monitoring and documentation plan will be addressed in the incident report, however as a minimum KCBL would expect that a new survey be undertaken to establish a benchmark crest level and thereafter a crest survey and evaluation incorporated as part of the annual inspection and reporting.

It is recommended that NTPC use this incident to evaluate the effectiveness of the existing EPP and address any shortcomings that were experienced in implementing and executing the emergency action plan.

In light of the warning signs indicated by the 2005 survey described above, this incident appears to have been avoidable. The procedural deficiencies likely precipitating the events that transpired are addressed in Section 10.

### 9.4.5 Freeboard Dyke 2 - Current Condition

At the time of the current inspection, NTPC staff reported that the dyke had very recently been topped up by approximately 0.6 m (2 ft) immediately following the breach at Freeboard Dyke 1, when the water level was reportedly 6 to 8 inches below the crest of Freeboard Dyke 2. The 2005 crest survey results (Figure 9-3) are therefore not representative of the conditions observed during the site inspection.

Although recently topped up, the crest exhibits an undulating profile with two visible depressions in the crest – one at each abutment - indicative of ongoing permafrost thaw (Photo 67). No longitudinal cracking was evident (Photo 68); however, cracking could have been masked by the recently placed sand fill. The downstream shoulder of the dyke appears lower than at the centerline (Photo 69), likely as a result of the hastily placed sand fill rather than an indication of settlement. The dyke design elevation should be reinstated for the full crest width. In this respect a new crest survey is recommended to determine the current profile and determine the amount of sand fill required to top up the dyke in order to reinstate the design level.

The upstream riprap is in acceptable condition (Photo 70). There is ponded water along the downstream toe originating from the foundation at the left abutment (Photo 71). Inspection along the toe revealed no single source point, but the clear water flowing along the toe (Photo 72) was estimated to be in the order of 1 to 2 L/s, resulting in a shallow pond of water at the deepest section (Photo 69). No documentation of seepage has been reported in either of the 2000 DSR or the 1990 inspection report and it is therefore recommended that the condition be closely monitored and documented by NTPC for any increases in flow and that a small weir be constructed in order to more accurately quantify the discharge.

Within about 30 m of the right abutment, four small boils were observed to be discharging within approximately 2 m of the toe of the dyke and beneath the ponded water. All discharges were crystal clear and the largest piping opening was in the order of 5 cm (based on a finger measurement). Quantifying flow was difficult due to the discharge being underwater, but was estimated to be not more than 5 L/min from the strongest flowing boil (Photo 73). The differential between the reservoir level and the ponded water was estimated to be not more than 1.5 m. Identifying the locations of the boils is very difficult unless closely scrutinizing the area and they would likely be missed during a cursory inspection of the dam toe or from the shoulder of the crest. The gradient between the reservoir and pond will increase during floods, and the boils may then have the potential to carry soil from the foundation. It is recommended that the boils be covered with “reverse filters” to prevent migration of soil from them.

### 9.4.6 Freeboard Dyke 3 - Current Condition

At the time of the current inspection, NTPC staff reported that the dyke had recently been topped up. The 2005 crest survey results (Figure 9-3) are therefore not representative of the conditions experienced during the site inspection.

The upstream riprap (Photo 74) is generally in a satisfactory condition with no beaching or erosion damage, but there are some areas where it is locally finer and ongoing monitoring is recommended. The crest of the dyke shows no signs of cracking but the requirement for ongoing topping up indicates continued permafrost thaw and settlement. Despite being recently topped up, the area toward the right abutment still appears low when compared to other points along the profile. A crest survey is recommended to confirm the crest profile and determine the fill requirements to reinstate the design crest level.

The downstream toe is dry with no evidence of seepage from either the foundation or fills.

### 9.4.7 Summary

As a minimum a new survey of all freeboard dykes must be carried out and design crest levels are to be reinstated. However a more robust course of action is recommended by determining the approximate annual settlement of each dyke using the survey results from previous years and then over building the crest levels of each by an amount equivalent to the predicted 5 year settlement (or other practical time interval based on the annual settlement estimate) and adding fill when the crest settles to its design level with a centreline survey undertaken every year as part of the annual inspection.

Ongoing visual monitoring of settlement should be maintained to identify future requirements for topping up low areas annually in the event that settlement rates exceed those predicted. The boils along the toe of Freeboard Dyke 2 should be covered with reverse filters to prevent soil migration.

## 9.5 Strutt Lake Dam and North Dyke

### 9.5.1 General

Strutt Lake Dam is zoned earth-rockfill dam with an upstream sloping core founded on bedrock, with sand and gravel filters and rockfill shells. The crest length is approximately 160 m with a maximum height of 18 m. The North Dyke is founded on overburden and extends 120 m north from the left abutment of Strutt Lake dam to close the reservoir. The design crest of the dams is EL. 176.78 m (EL. 580.0 ft), with 1.2 m (4 ft) of granular fill over the top of the core. The project layout is illustrated on Figure 9-1 with typical cross sections on Figure 9-2.

### 9.5.2 Operational Performance

No safety concerns were identified in previous inspection reports of the Strutt Lake dam and North Dyke. Previous inspections have routinely reported minor seepage around the powerhouse which is situated at the toe of the dam; in the 2000 DSR the seepage was attributed to run-off and/or precipitation rather then seepage through the dam abutments and foundation as previously suspected.

### 9.5.3 Instrumentation and Monitoring

Three standpipe piezometers were installed in the localised wet area downstream of the left abutment of the dam (Photo 75) in March 2000, where earlier drilling showed a granular layer under minor artesian head overlying bedrock. NTPC do not have a record of piezometer measurements and discussion with site staff confirmed they are not read. Field observation during the current inspection indicated that the heads of the standpipe piezometers have been destroyed, likely during snow removal activities around the switchyard. It is recommended that the piezometer heads are reinstated and readings re-implemented.

A rock fill French drain has been constructed as recommended in the previous DSR to help drain the area (Photo 76). It is not typically monitored and was dry at the time of inspection.

An August 2005 centreline survey (see Figure 9-4) shows the crest of Strutt Lake Dam ranging from EL. 176.82 m (EL. 580.1 m) to EL. 176.94 m (EL. 580.5 ft), all above design grade. The survey also shows the North Dyke crest elevation ranging from EL. 176.72 m (EL. 579.79 ft) to EL. 176.95 m (EL. 580.5 ft), i.e. within 0.06 m of design level. The North Dyke has been topped up since the 2005 survey and the most current survey therefore does not reflect the conditions at the time of the inspection. A new crest survey is therefore considered prudent to document current conditions.

### 9.5.4 Current Condition

Inspection showed the dam to be in satisfactory condition with no discernable changes from the last DSR inspection in 2000. The crest is planar, with no visible settlement, cracks or erosion (Photo 77). The downstream shell of the dam is planar with no settled areas, erosion gulleys or evidence of abutment seepage (Photo 78). The localized wet area between the toe of the dam and switchyard still exists but to a lesser degree than in 2000 as a result of the drain construction. Some winter ice build-up is still reported by NTPC staff. The riprap on the upstream slope is satisfactory and shows no signs of breakdown, beaching or deterioration, except in the vicinity immediately to the left of the intake where some larger size particles appear to be lacking (Photo 79). NTPC staff should visually monitor this area for any signs of deterioration in which case the localized area should be redressed with appropriately sized material.

A heat traced, perforated PVC pipe encased in a gravel drainage layer has been installed along the southwest side of the powerhouse (Photo 80) to address the minor seepage which has been observed from the rockfill downstream of the powerhouse and assessed in previous inspections as originating from the dam abutments and foundation. However, the PVC pipe does not daylight and seepage measurements cannot be made. There are still signs of dampness along the southwest side of the powerhouse (Photo 81), but there is no longer observable seepage. NTPC site staff report no adverse changes in this respect.

There is minor seepage still occurring through the bedrock near the southeast corner of the powerhouse and switchyard as evident by the ponded water at the switchyard retaining wall (Photo 85). This seepage has been reported during previous inspections and is not considered a dam safety issue. NTPC should continue to visually monitor existing leakage and report any evidence of increase for review.

The North Dyke had recently been topped up at the time of inspection and appeared to be in satisfactory condition. The crest is planar with no cracks, settled areas or erosion (Photo 82). The riprap on the upstream face provides suitable protection and shows no significant deterioration, beaching or breakdown (Photo 83). The downstream shell is planar, with no erosion gulleys or evidence of seepage (Photo 84).

### 9.5.5 Stability

The stability of Strutt Lake Dam was assessed in the previous DSR where it was concluded that stability under normal service and extreme loading conditions would meet current CDA guidelines and USBR/USACE design criteria.

There has been no new information, since the pervious assessment that would require a re-evaluation of the dyke stability. Although our current assessment of the MDE (1,000 yr AEP earthquake) may possibly be considered a changed load condition (it is not clear what AEP earthquake was considered in the previous stability assessment, but is suspected to be the 475 yr event from the NBCC (1995)), an earthquake with peak ground acceleration of 0.035 g is not expected to govern the design. No stability issues are identified.

### 9.5.6 Summary

The Strutt Lake Dam and North Dyke are generally in satisfactory condition with no evidence of significant deterioration or developing performance problems. Riprap on the upstream face of Strutt Lake Dam immediately left of the intake should be monitored and redressed as required. NTPC should continue to visually monitor existing leakage and report any evidence of increase for review. A new crest survey of Strutt Lake dam and North Dyke freeboard dykes is recommended and results evaluated to ensure design crest levels are maintained.

## 9.6 Intake

### 9.6.1 General

The concrete intake structure is founded on bedrock. Figure 9-2 shows a section through the structure. The gate hoist is housed within a steel sheet insulated enclosure supported by a reinforced concrete floor slab and beam in turn supported by two reinforced concrete columns. A steel frame superstructure is provided for stoplog handling.

### 9.6.2 Operational Performance

The 2000 DSR reported the concrete and steel superstructure as appearing in good condition. NTPC report no performance related problems during past operations.

### 9.6.3 Instrumentation and Monitoring

There is no instrumentation specific to the Snare Forks intake.

### 9.6.4 Current Condition

During the 2006 KCBL inspection, the water level was high (EL. 174.34. m) which limited the inspection of the substructure. The reinforced concrete columns, beam and floor slab superstructure appeared in good condition. Likewise the steel frame superstructure for stoplog handling is in good condition (Photo 86).

The insulated sheet steel enclosure is functional but requires painting. The interior face of the walls consists of asbestos liner sheets.

In general, the intake structure is in satisfactory condition but painting of the sheet steel cladding is required as a maintenance issue.

### 9.6.5 Electrical and Mechanical Equipment

No maintenance or test records were available during the site visit and the gate could not be tested during the site visit due to operating requirements.

The intake gate could not be observed as it was under water. The intake hoist equipment was observed to be in good condition.

### 9.6.6 Stability

No stability check was carried out on the Snare Forks intake in the previous DSR. A stability check of the intake is required in accordance with CDA Dam Safety Guidelines Sections 2.2.3 and 9.0. The only structural information available for this DSR relating to the intake is the sketch type figures from previous reports and site observations of visible components which is insufficient to perform a complete evaluation. Although this structure has performed satisfactorily since construction; no displacement or distress was observed; the MDE is low and the proportions such as base width to height appear reasonable, a structural stability review is recommended to comply with CDA guidelines.

### 9.6.7 Summary

The intake structure is in satisfactory condition but the high water level limited the inspection of the substructure. The operational testing and maintenance program as laid out in the OMS manual complies with dam safety requirements, but there was no available documentation to record previous tests. Structural stability review for seismic loading is required to comply with CDA guidelines.

## 9.7 Power Tunnel

The power tunnel is founded on rock and consists of a steel penstock encased in concrete as shown on Figure 9-2. A bifurcation is provided to supply the two units. The power tunnel was not accessible during the inspection and no references are found to any previous inspections. A power tunnel inspection is therefore recommended during the next planned outage to document conditions.

## 9.8 Powerhouse

The powerhouse, located at the toe of the dam, comprises a reinforced concrete substructure to approximately 3 m above the main (generator) floor; a braced structural steel frame superstructure in the cross direction; steel moment frames in the upstream – downstream direction; and steel sheet cladding above ground floor (Photo 87). The powerhouse contains two vertical shaft Francis-type turbine-generator units with a combined rated capacity of approximately 9.2 MW. The units were operating at the time of the inspection.

The powerhouse appeared to be generally in good condition in July 2006, but is not considered to be dam safety related and was therefore not thoroughly inspected. Any operational and maintenance issues observed during the facility visit will be transmitted separately to NTPC.

# 10. OPERATION, MAINTENANCE AND SURVEILLANCE

NTPC provided a copy of the Operations, Maintenance and Surveillance (OMS) manual for review. It was available in print form in some of the powerhouses and available in electronic format on the NTPC computer system.

The CDA guidelines address only OMS issues related to dam safety and are not intended to be applied to non-dam-safety issues. The OMS manual for the Snare Hydro system is a comprehensive document which addresses both types of issues. Given the relative simplicity of the dam safety issues (mainly, operation of gates or stoplogs at some plants), it is logical that all OMS items are addressed in one document. However, the dam safety aspects should be clearly identified as such.

The document is undated and the locations or holders of copies of the document are not identified. This should be remedied, so it is clear when the document was last updated and where copies are located so that all copies are updated.

The section on dam classification should be updated to reflect the inflow design flood determined during the 2000 DSR. The capacity of Snare Cascades spillway is missing and should be filled in.

The document uses the term “Hydro Officer” but KCBL is not aware that this is a formal position within NTPC.

Instructions are given for gate and stoplog operations and, generally, references to drawings and manuals are provided. In the section Snare Falls Spillway, the drawing number referenced for wheels, seals, heaters, etc is missing.

The maintenance program is described. We understand that testing is performed but did not see documentation confirming that it had been done recently.

The OMS manual includes forms to be filled out during surveillance inspections that are required every four days for all structures, as well as annually by the Hydro Officer and the Hydro Facilities Engineer. KCBL were not provided with any completed inspection forms to illustrate that the inspections are, indeed, performed.

The only instrumentation, temperature measurements in the core of Snare Rapids Dam, is documented in the manual. The requirements for monitoring seepage, for reading piezometers at Strutt Lake Dam, and for crest surveys of dams and dykes should be described.

Procedures for flood forecasting and reservoir control are described for the reservoirs with gated spillways. However, the manual indicates that the "water officer" will order the removal of stoplogs or gate opening. From our discussions with NTPC personnel, we are not clear that the "water officer" is a clearly defined position. This should be clarified.

Maintenance requirements are described and we understand from discussions at site that the work is performed. However, KCBL personnel were not provided with recent maintenance records to confirm the work is performed.

The failure of Snare Forks Freeboard Dyke No. 1 in 2006 illustrates a significant deficiency in the OMS procedures for dam safety. The dyke crest was surveyed in 2005 and shown to be as much as 2.1 m below design elevation, yet there was no action taken to remedy the situation. The other freeboard dykes at Snare Forks also showed large crest settlements, with local areas of the crests below the maximum operating level. A Dam Safety Officer should be responsible for all dam safety aspects, including review of survey and instrumentation data, review of inspection reports, identification of real or potential deficiencies, and remediation, including all associated documentation. The Dam Safety Officer should also be responsible for dam safety aspects of the OMS manual and for the Emergency Preparedness Plan.

# 11. EMERGENCY PREPAREDNESS PLAN

KCBL was provided with a copy of the Snare Hydro Emergency Preparedness Plan. The document was reviewed for compliance with the requirements of Section 4 of the Dam Safety Guidelines.

The document is undated, and appears to be an excerpt from a larger document (the EPP page numbers are 20 to 47). It should be dated, and should also indicate the distribution of the document so that when updates are prepared, all document holders receive those updates.

Notification information (telephone numbers) is given in two locations in the EPP. These should be consolidated to one location to minimize the possibility that numbers are not updated, when necessary, in one of the locations.

Various titles are used, and it is not clear who is the actual person or office that is referenced. For example, OS (Operations Superintendent) is defined, but there is no telephone number identified for the OS. It is not clear whether the OS is in effect the Manager Hydro Operations, or the Director, Central Operations. The Vice President of Operations and Director of Security and Safety are referenced in Section 4.4, but no telephone numbers are given for those positions. Section 1.2.2 states that the "Regional Director shall report…" However, no person with that title is listed in the document. Titles should be precise and correct in order to minimize the potential for miscommunications.

The hazard classifications given in Section 3 should be updated to the subsequent assignments of the 2000 DSR. Section 4.5.3.2, Spillway Design Discharge, should be updated to reflect the updated Inflow Design Flood determined during the 2000 DSR. Section 6.4.1 refers to navigation aids that "are being installed in the summer of 2000." The document should be updated to reflect current conditions and knowledge.

The EPP should include inundation maps. Given the lack of development in and downstream of the plants, it may be sufficient to only identify whether and where the all season road would be flooded in the event of a breach of each structure, so it is evident when alternative access (likely by air) would be required.

The CDA Guidelines note that the EPP shall be tested and training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP. There is no record of testing or training.

# 12. SECURITY

The Snare River sites are generally remote with no road access except in winter. The vehicle sensor in the road at the Snare Forks intake structure is the only sensor system noted by Operating staff during the site visit. Station doors and fenced areas are generally locked and restricted areas are all fenced.

Once past the road sensor, or if visitors come via boat or air, there is no positive means to detect intruders into station properties other than direct observation by station personnel.

Most gate operations that would affect fishermen or boaters are performed from local control panels, so the hazards are minimal because operators have a clear view of the affected area.

Floating booms are suggested in front of spillways that are open for the summer months.

Although no history of vandalism was noted by the Operators during our site visit, there is potential for intruders to gain access to generation facilities and cause damage either accidentally or intentionally. Critical flow discharge facilities such as the 5B spillway and the Snare Falls spillway should have additional surveillance.

Additional security at the plants could be easily and inexpensively achieved through the use of remote video cameras on the company intranet or over the phone lines. Surveillance technology has become smaller and less expensive, and enables remote monitoring of several cameras from the staff house or any of the four control rooms.

# 13. COMPLIANCE WITH PREVIOUS REVIEWS

Table 13.1 summarizes the recommendations of the 2000 DSR and their current status where this has been documented or we were advised during the 2006 inspection. Table 13.1 also includes a proposed classification system to prioritize the dam safety recommendations, as follows:

| Class | Response Time |
|---|---|
| Very High (VH) | Immediate |
| High (H) | Within 1 year |
| Medium (M) | Within 5 years |
| Low (L) | Within 10 years |

Many of the items in Table 13.1 are, in KCBL’s judgment, maintenance items and were not dam safety issues. These are identified in the table.

**Table 13.1 Snare Hydro – Status of Dam Safety Recommendations from 2000 Dam Safety Review**

| Structure | Recommendations 2000 | Classification | Status 2006 |
|---|---|---|---|
| General | The frequency of crest surveys to monitor crest settlement be reduced to once every five years. | M | Implemented |
| | Intake and spillway gates be raised above water level and inspected. Thickness measurements using ultrasonic equipment be taken where there is evidence of corrosion and pitting. | M | Outstanding |
| | Toe boards be installed along the bottom of handrails. | M | Maintenance Item |
| | Operating instructions for equipment be posted near associated equipment. | H | Outstanding |
| | Qualified professional engineers inspect power tunnels, penstocks and conduits prior to the next dam safety review. | M | Completed for Snare Rapids power tunnel only. |
| | Operation of spillway gates and hoists be witnessed by professional engineers prior to the next dam safety review. | M | Not done |
| | Visual monitoring by NTPC staff supplemented by a documented annual inspection report continue. | H | No records provided |
| | A maintenance program be established for the cleaning and painting of intake, spillway and draft tube gates. | M | Maintenance Item |
| | An independent professional engineer knowledgeable in the design and construction of water retaining structures should accompany NTPC and DIAND personnel during one of the annual inspections between dam safety review periods. | M | [To be confirmed by NTPC] |

| Structure | Recommendations 2000 | Classification | Status 2006 |
|---|---|---|---|
| | Dam Safety reviews be carried out every five years. | M | Completed |
| Monitoring | Monitoring of leakage from the Snare Rapids power tunnel continue on the present schedule. | H | Ongoing |
| | The weir installed in 1999 by NTPC at the Snare Rapids Side Dam 5B requires maintenance next summer to seal minor leaks along the base of the weir would improve its accuracy. Readings should continue to be taken every three months. | H | Not completed |
| | A culvert through the downstream cofferdam at the Snare Forks Main Dam with a V-notch weir be installed to allow periodic measurement of leakage from this dam. | H | Completed |
| | A gravel filled French drain with an outlet culvert to drain the wet area immediately downstream of the left abutment of the Strutt Lake Dam be installed to allow more accurate monitoring of leakage from this area. | H | Completed |
| | Readings be taken at bi-weekly for the first year after installation of these weirs, along with the three Strutt Lake Dam left abutment standpipes installed to monitor the downstream “wet area”. The frequency of readings can then be reduced to every 3 or 4 months until the next dam safety review. | H | Not completed. Piezometers never read. |
| Snare Rapids | The brake pads on the intake hoist be replaced. | H | Maintenance Item |
| | A protective cover be installed over the push-button controls on the intake hoist. | M | Maintenance Item |
| | The ventilation provided for the Battery Room in the powerhouse be upgraded to meet Canadian Electrical Code standards. | H | Maintenance Item |

| Structure | Recommendations 2000 | Classification | Status 2006 |
|---|---|---|---|
| | Consideration be given to raising the core of the Main Dam (recommendation from the Phase 1 Review) | M | Completed |
| | The William Kennedy Stoplog lifter hoist equipment at the 5B spillway requires lubrication. | H | Completed |
| | The backup gasoline engine should be connected and commissioned. | H | Completed |
| | A concrete rehabilitation program be established to repair cracking around stoplog gains at Spillway 5B and to protect the downstream toe of the piers in Bays 3 and 4 from erosion. | M | Program not implemented |
| | The condition of the downstream berm at Side Dam 4 be carefully evaluated in future annual inspection by NTPC staff. | M | No documentation of annual inspections provided |
| | Fine rockfill or crushed gravel be placed on the upstream face of Side Dam 9B. | M | Not completed |
| Snare Falls | The wire mesh mounted on the air intake damper of the generator is too fine and should be changed to a coarser opening. | M | Maintenance Item |
| | Safety latches should be installed on the stoplog hoist hooks. | M | Maintenance Item |
| | The skin plate panels on the spillway gates should be analyzed for structural strength after thickness measurements are taken. | M | Not completed |
| | The broken sealing rod on Gate No. 1 should be replaced and the sealing hold down clamps rehabilitated. | H | Maintenance Item |
| | Consideration should be given to heating and cladding Gate No. 2 in order to provide emergency backup in the event Gate No. 1 cannot be | M | Outstanding |

| Structure | Recommendations 2000 | Classification | Status 2006 |
|---|---|---|---|
| | operated in the winter. | | |
| | The hoist controls at the spillway and the stoplog hoist should be painted. | M | Maintenance Item |
| Snare Cascades | The right abutment of the spillway be inspected after the snow has melted and additional erosion protection placed. | H | Implemented measures temporary in nature and only partially successful. |
| Snare Forks | The brake pads on the intake hoist be replaced. | H | Maintenance Item |
| | The diesel generator exhaust in the powerhouse be insulated. | M | Maintenance Item |
| | The fire system in the powerhouse be upgraded to meet NFPA standards. | H | Maintenance Item |
| | The insect screen on the powerhouse outdoor air intake louver be replaced with a coarser screen during the winter to prevent frost build up. | M | Maintenance Item |
| | An eaves trough installed at the lower roof of the powerhouse to prevent ice from falling onto the intake louvers. | M | Maintenance Item |

# 14. CONCLUSIONS AND RECOMMENDATIONS

Notwithstanding the events surrounding the failure of Freeboard Dyke 1 in June 2006 which will be addressed by others in a separate report, the Snare Hydro development, specifically the facilities of concern to dam safety, is in generally satisfactory condition and is well maintained, with no significant apparent deterioration or evidence of problems which could effect the safety and serviceability of the structures.

Table 14.1 summarizes the actual and potential deficiencies identified during the current DSR. Outstanding dam safety issues from the 2000 DSR recommendations are repeated in Table 14.1, so it is a comprehensive summary of deficiencies.

The classification in Table 14.1 prioritizes the response times for implementation of the recommendations, as follows:

| Class | Response Time |
|---|---|
| Very High (VH) | Immediate |
| High (H) | Within 2 years |
| Medium (M) | Within 5 years |
| Low (L) | Within 10 years |

The response time for the High Class is lengthened compared to that of the 2000 DSR, to permit winter roads to be used in 2007/2008 for those measures which require mobilization of heavy plant and equipment.

Appendix V presents a detailed summary of the CDA (1999) dam safety guidelines and the status of Snare Hydro facilities regarding conformance to those guidelines.

## Table 14-1 Snare Hydro - Recommendations Arising from 2006 Dam Safety Review

| Structure | Recommendation | Classification |
|---|---|---|
| All | Update reference drawings to show current arrangements. | M |
| | Identify dam safety related items in OMS. | M |
| | Distribution of OMS and EPP documents to be identified in both publications. | H |
| | General update of OMS and EPP to current conditions and knowledge, e.g. consequence classification, IDF, rating curve data etc. | H |
| | The water officer described in the OMS should be defined. | M |
| | Update names and contact information of listed titled positions in OMS and EPP. | H |
| | EPP should include inundation maps. | H |
| | EPP should be tested and results recorded. | H |
| Snare Rapids Main Dam | Reinstate design crest level over full length of dam. | M |
| | Confirm crest profile reinstatement with new survey. | M |
| | Brush crest and slopes, remove woody debris from upstream slope and maintain areas. | H |
| | Institute seasonal readings of core thermistor as a minimum monitoring frequency. | H |
| Snare Rapids Intake | Repair cracks in reinforced concrete substructure. | M |
| | Review stability of intake. | M |
| Snare Rapids Power Tunnel | Implement program of investigation and analysis recommended by BGC Consultants during next planned annual shutdown. | H |
| Snare Rapids Spillway 5B | Replace second stage concrete around heated gains in spillway Bay 3 and 4. | H |
| | Inspect and document Bay 3 when conditions permit. | M |
| | Replace/repair bulge and tear in left side steel embed of spillway Bay 4. | H |
| | Repair cracks in spillway deck expansion joints. | M |
| | Repair undercutting at concrete/rock interface of piers between Bays 3, 4 and 5. | M |
| | Clear vegetation from base of spillway piers. | M |
| | Review seismic stability with 1000 year MDE loading. | M |
| | Consider adding additional surveillance. | M |

| | | |
|---|---|---|
| Snare Rapids Side Dam 5B | Extend measuring weir so all inflows can be collected and measured. | M |
| | Survey crest to determine current profile. | M |
| | Brush crest and slopes, remove woody debris from upstream slope and maintain areas. | M |
| Snare Rapids Side Dam 4 | Replace areas of missing and undersized riprap on upstream face. Areas near left abutment require particular attention. | H |
| | Brush crest and slopes, remove woody debris from upstream slope and maintain areas. | M |
| | Place 30 cm thick layer of fine rockfill or crushed gravel on upstream face to prevent erosion from wave action. | M |
| | Remove large raft of woody debris accumulating in the waterway in front of the dam. | M |
| | Survey crest to confirm design crest level is maintained. | H |
| Snare Falls Main Dam | Brush crest and slopes, remove woody debris from upstream slope and maintain areas. | M |
| Snare Falls Spillway | Report monitoring of vertical cracks in stoplog guide concrete and document in annual inspection. | H |
| | Perform ultrasonic thickness testing to determine extent of gate skin plate corrosion. | M |
| | Install reliable electric supply system consisting of redundant supply sources. | H |
| | Make second spillway gate suitable for winter operation. | M |
| | Rectify deficiencies noted in OMS. | M |
| | Review seismic structural stability with 1000 year MDE loading. | M |
| | Consider adding additional surveillance. | M |
| Snare Falls Intake | Perform ultrasonic thickness testing to determine extent of gate skin plate corrosion. | M |
| | Review structural stability. | M |
| Snare Falls Power Tunnel | Dewater, inspect and document condition. | M |
| Snare Falls Saddle Dam No. 1 | Brush upstream slope and maintain areas. | M |
| Snare Falls Saddle Dam No. 2 | Brush crest and slopes and maintain areas. | H |
| Snare Cascades Spillway | Inspect and document the significant crack in the twin box culvert structure beneath the spillway during the next low reservoir period. | M |
| | Undertake permanent repair to address erosion at the right abutment. | M |

| | | |
|---|---|---|
| Snare Cascades Power Canal Dyke | Survey crest to confirm that remedial works are adequate. | M |
| | Brush downstream slope, remove woody debris from slope and maintain areas. | M |
| Snare Forks Spillway | Inspect and document spillway control structure condition when water levels fall below crest. | M |
| Snare Forks Dam | Replace riprap locally on upstream slope. | L |
| Snare Forks Freeboard Dykes - General | New survey of all freeboard dykes must be carried out and design crest levels are to be reinstated. Overbuild recommended as described in the text. | H |
| Freeboard Dyke 1 | Evaluate effectiveness of EPP and address shortcomings experienced during incident implementation. | H |
| Freeboard Dyke 2 | Cover boils with a “reverse filter” to prevent migration of soil from them. | H |
| | Construct small weir along left abutment to monitor flow along toe. | H |
| Strutt Lake Dam and North Dyke | Reinstate 3 piezometers at the toe of dam and reintroduce monitoring program. | M |
| | Survey crest to document current conditions. | H |
| Snare Forks intake | Review structural stability. | M |
| Snare Forks Power Tunnel | Undertake power tunnel inspection to document conditions. | M |

# 15. DISCLAIMER

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The analyses, conclusions and recommendations contained in this report are based on information derived from various historic documents – reports, drawings, etc. – provided by Northwest Territories Power Corporation. Klohn Crippen Berger Ltd. has relied upon this information to make reasonable assumptions, where necessary, and to reach conclusions regarding the condition and performance of the structures at the Snare Hydro facilities. Klohn Crippen Berger Ltd. shall not be responsible for inaccurate or incorrect information provided in those documents.

KLOHN CRIPPEN BERGER LTD.


Garry Stevenson, P.Eng.
Project Manager

John Nunn, P.Eng.
Project Reviewer

# 16. REFERENCES

1.) Acres International (Acres), 1998. Dam Safety Inspection Snare and Taltson Hydroelectric Developments – Draft. October.

2.) Agra Monenco Inc., 2000. Snare Hydro Dam Safety Review, Phase 1, Volume 2 – Dam Safety Inspection. November.

3.) Agra Monenco Inc., 2000b. Snare Hydro Dam Safety Review, Phase 1, Volume 1 – Design Review. November.

4.) BGC Engineering Inc. (BGC), 2005. Project Memorandum from Holger Hartmaier to Colin Stang dated 04 November 2005, titled, “Snare Rapids Power Tunnel Inspection Field Memo – Final”.

5.) Canadian Dam Association (CDA), 1999. Dam Safety Guidelines. January.

6.) Department of Indigenous Affairs and Northern Development (DIAND), 1999. Hydroelectric Dam Inspection Reports October 13, 1999 and accompanying photos, transmitted to NTPC November 5, 1999, file N1L4-0150 for Snare Rapids, Snare Falls, and Snare Forks; file N1L4-1624 for the Snare Cascades inspection report.

7.) Klohn Crippen, 2005. Northwest Territories Power Commission, Twin Gorges Expansion Consolidated Summary Report. February.

8.) Land and Water British Columbia Inc., 2000. British Columbia Dam Safety Regulation.

9.) National Research Council Canada (NRC), 1995. National Building Code of Canada, Institute for Research in Construction.

# FIGURES

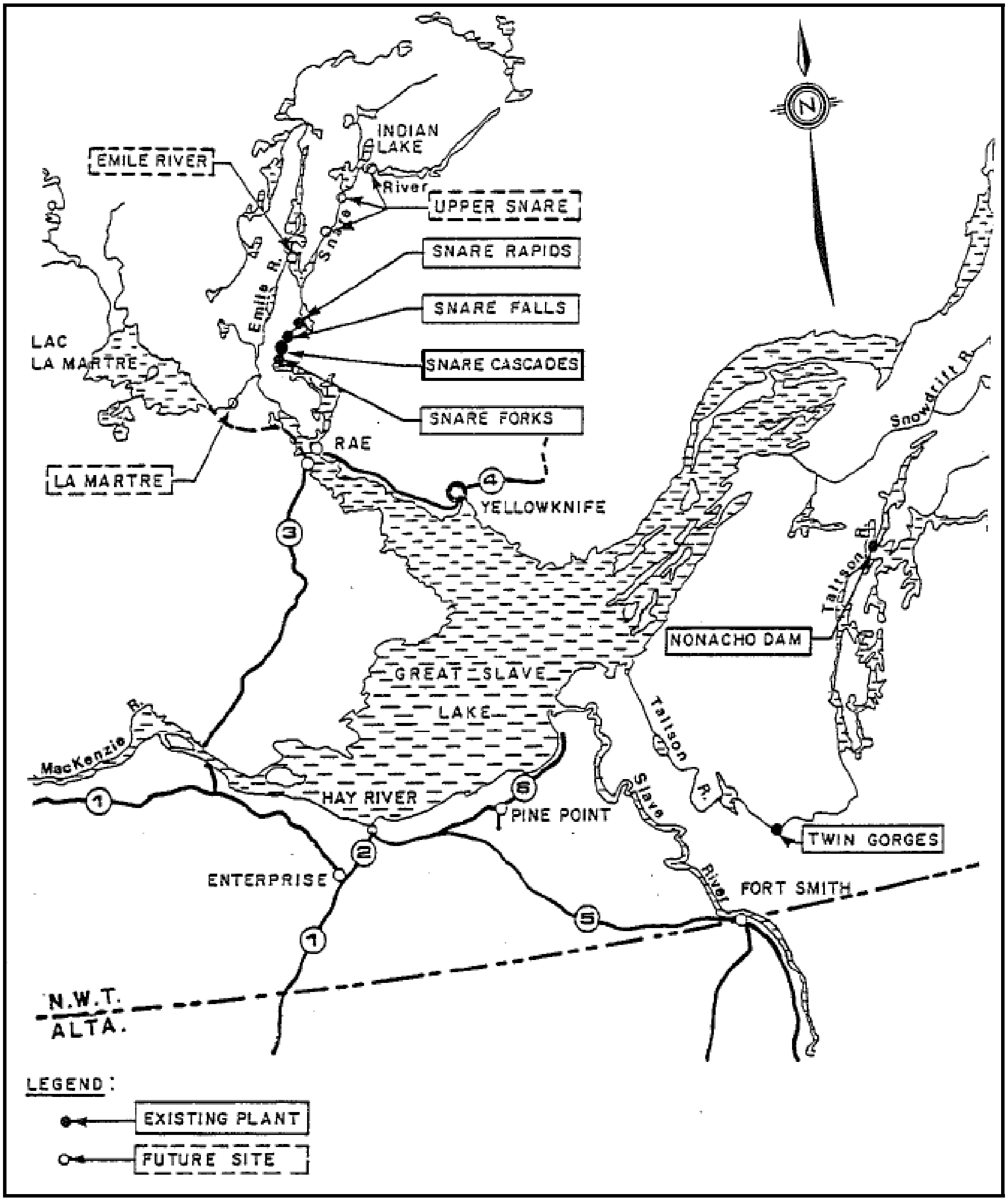



**Figure 1-1**: Snare Hydro Development – Regional Location Plan

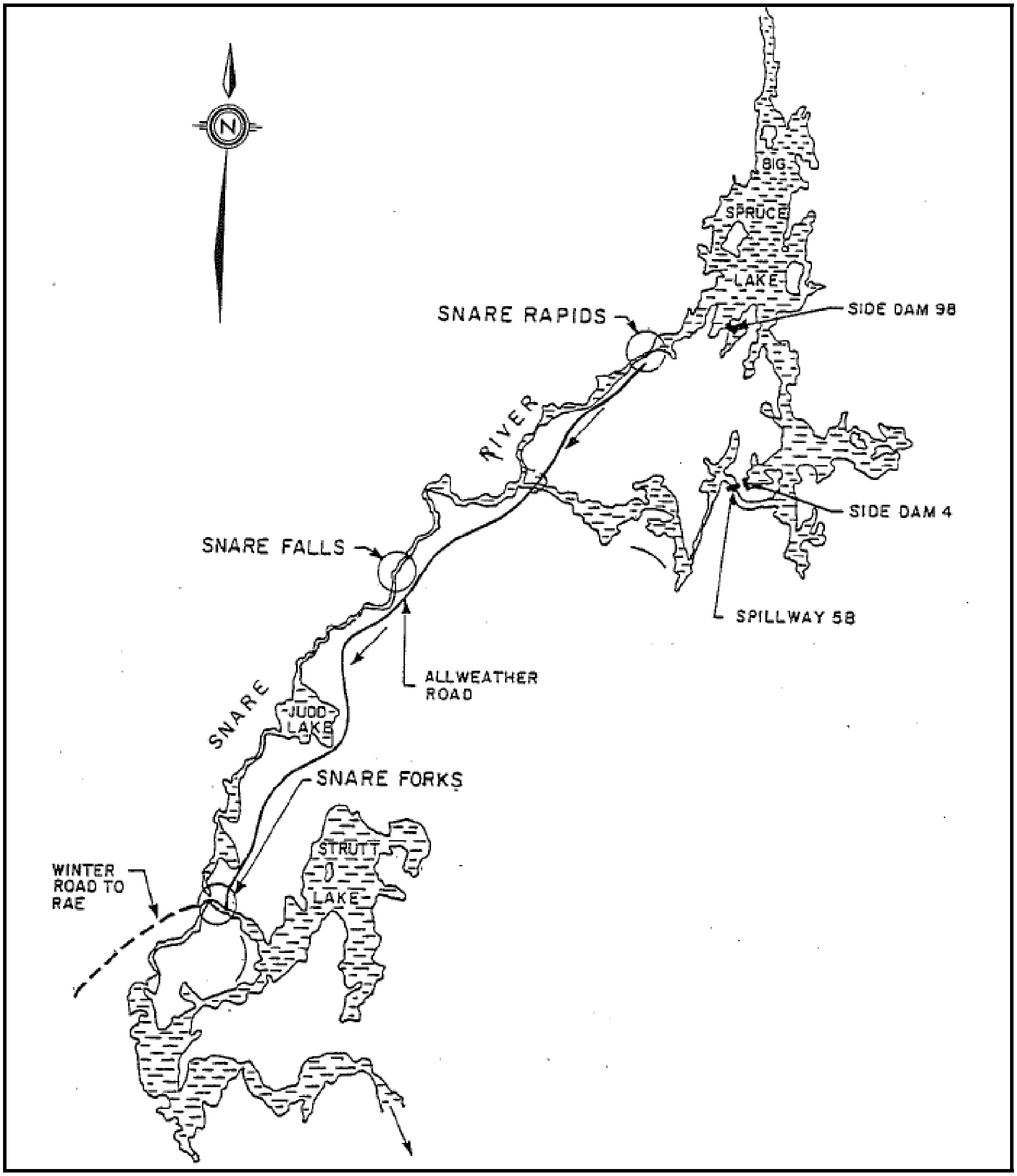



**Figure 1-2**: Snare Hydro Development – Facilities Development

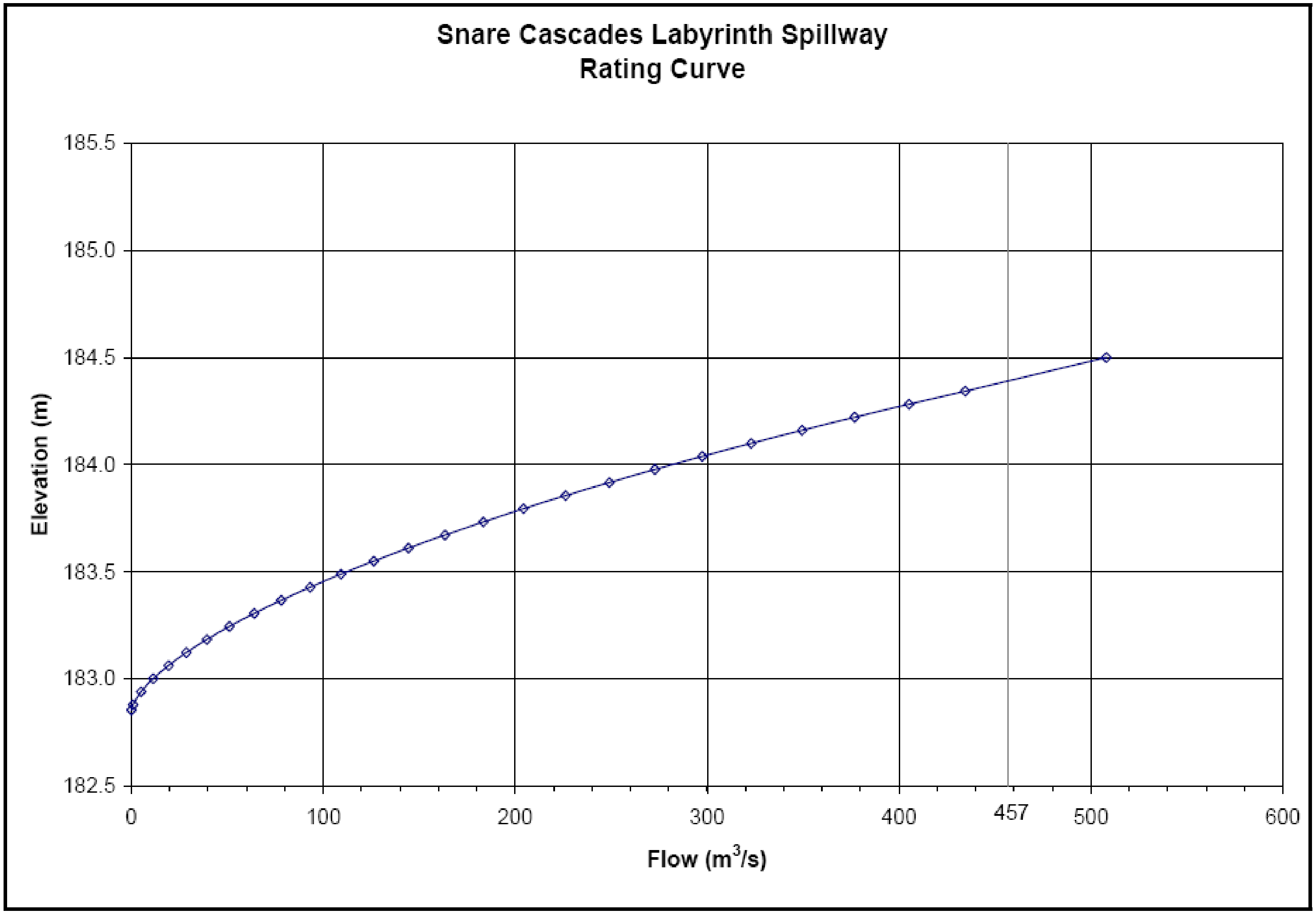



**Figure 4-1**: Snare Cascades – Labyrinth Spillway Rating Curve

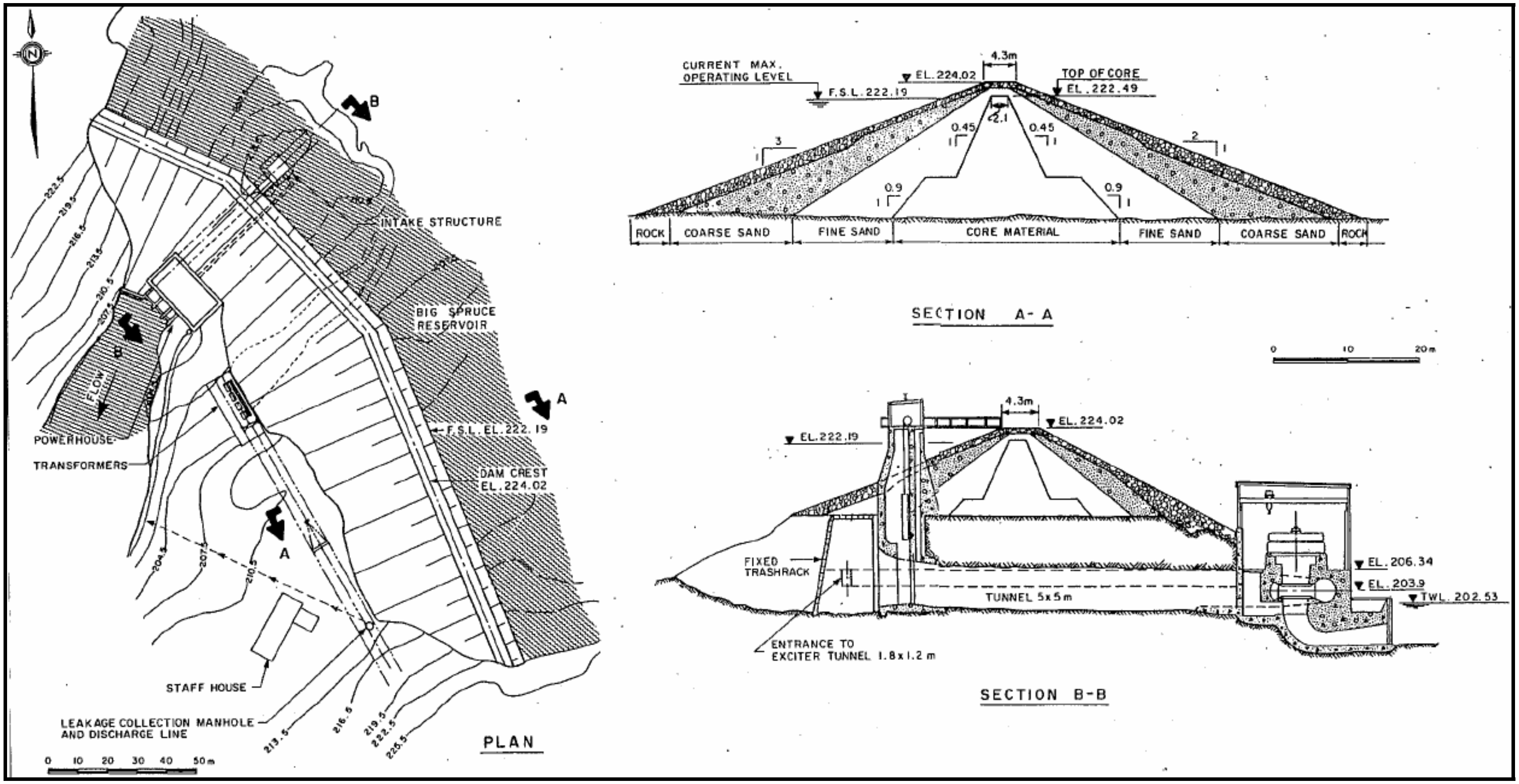



**Figure 6-1**: Snare Rapids G.S. – Layout and Typical Sections

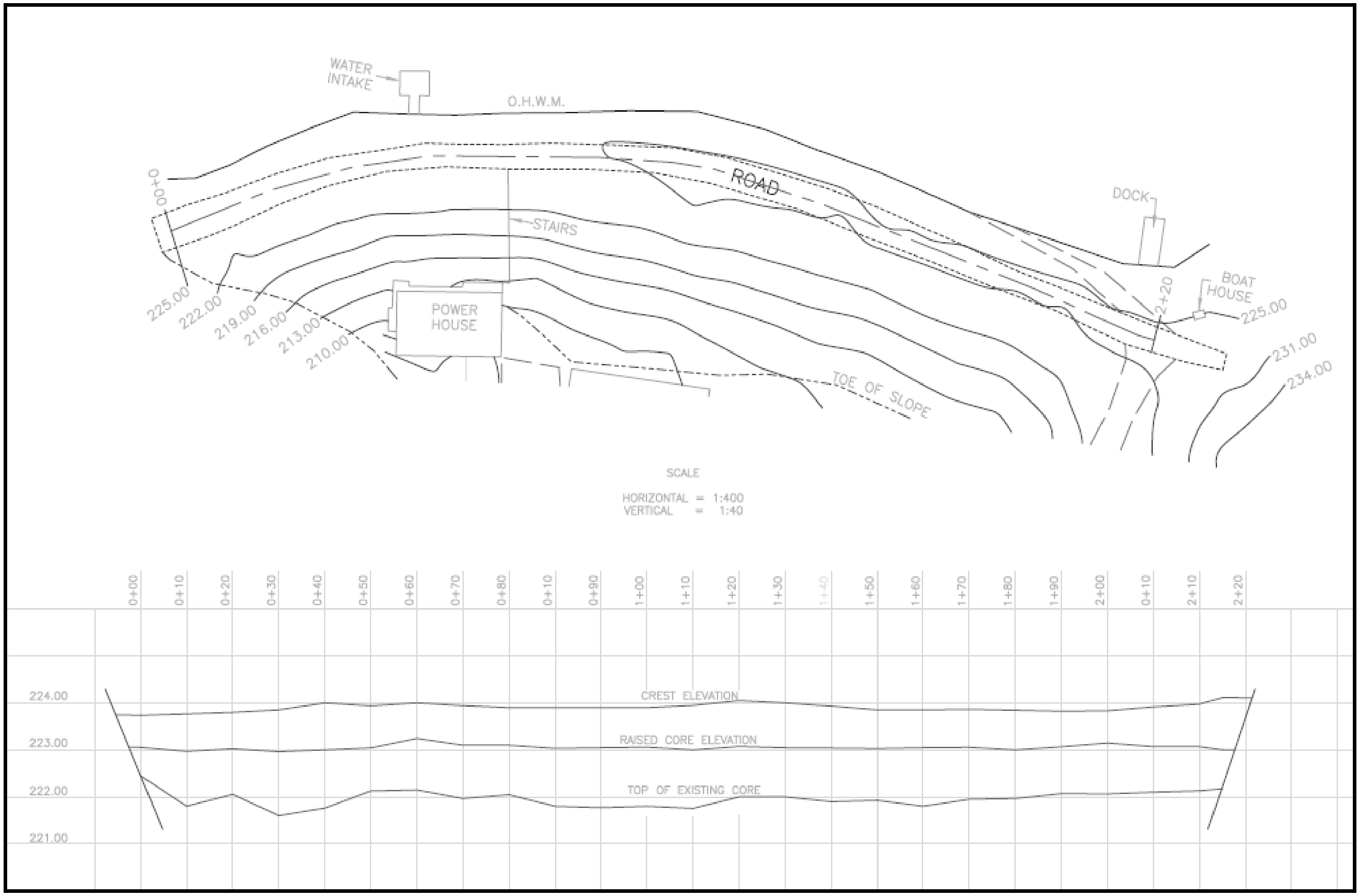



**Figure 6-2**: Snare Rapids Main Dam – Crest and Core Profile (2002 Survey)

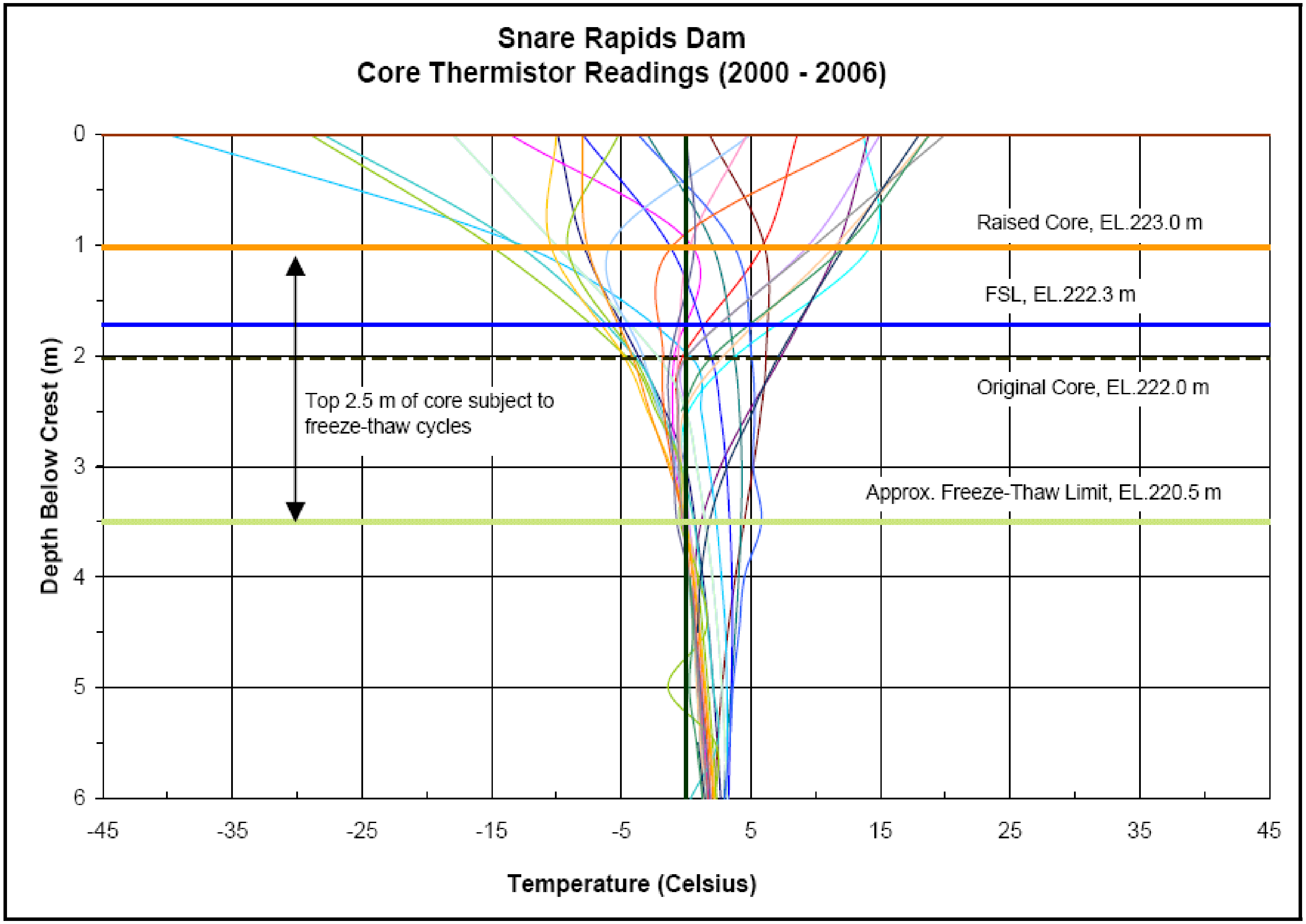



**Figure 6-3**: Snare Rapids Main Dam – Core Thermistor Readings (2000 to Present)

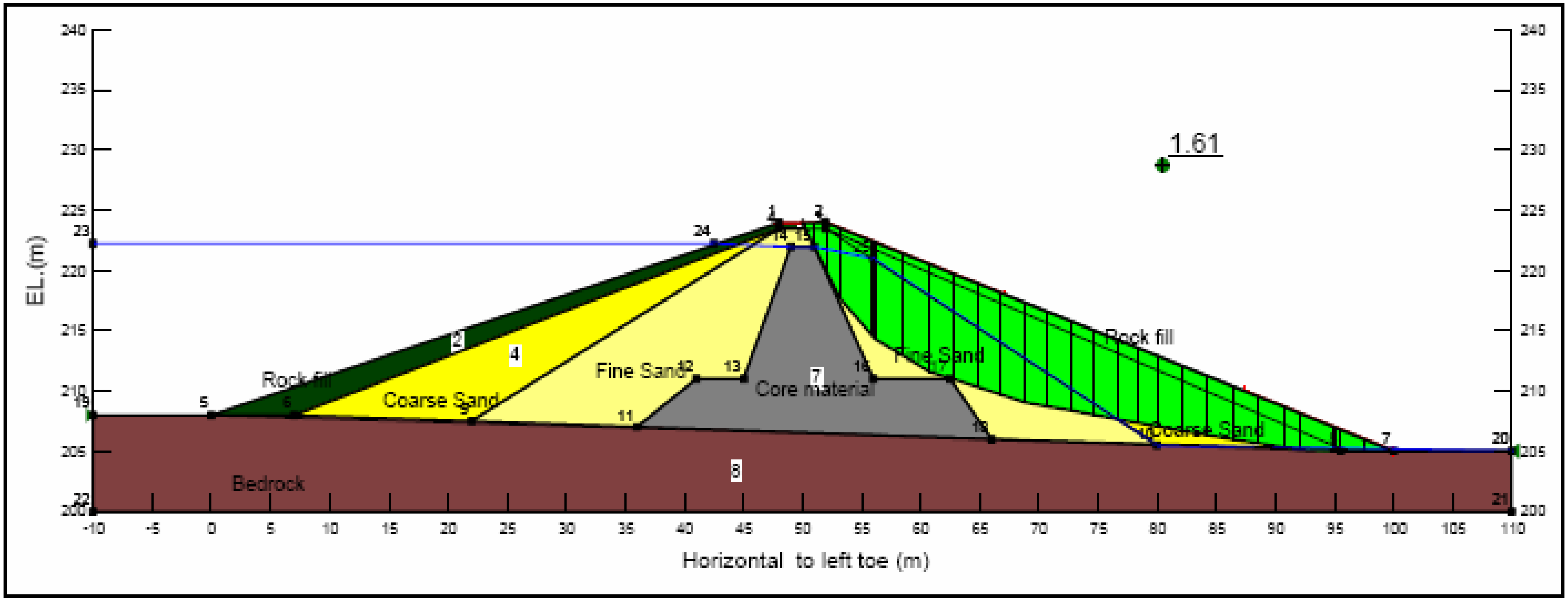



**Figure 6-4**: Snare Rapids Main Dam – Stability (Normal Load Case, FS = 1.61)

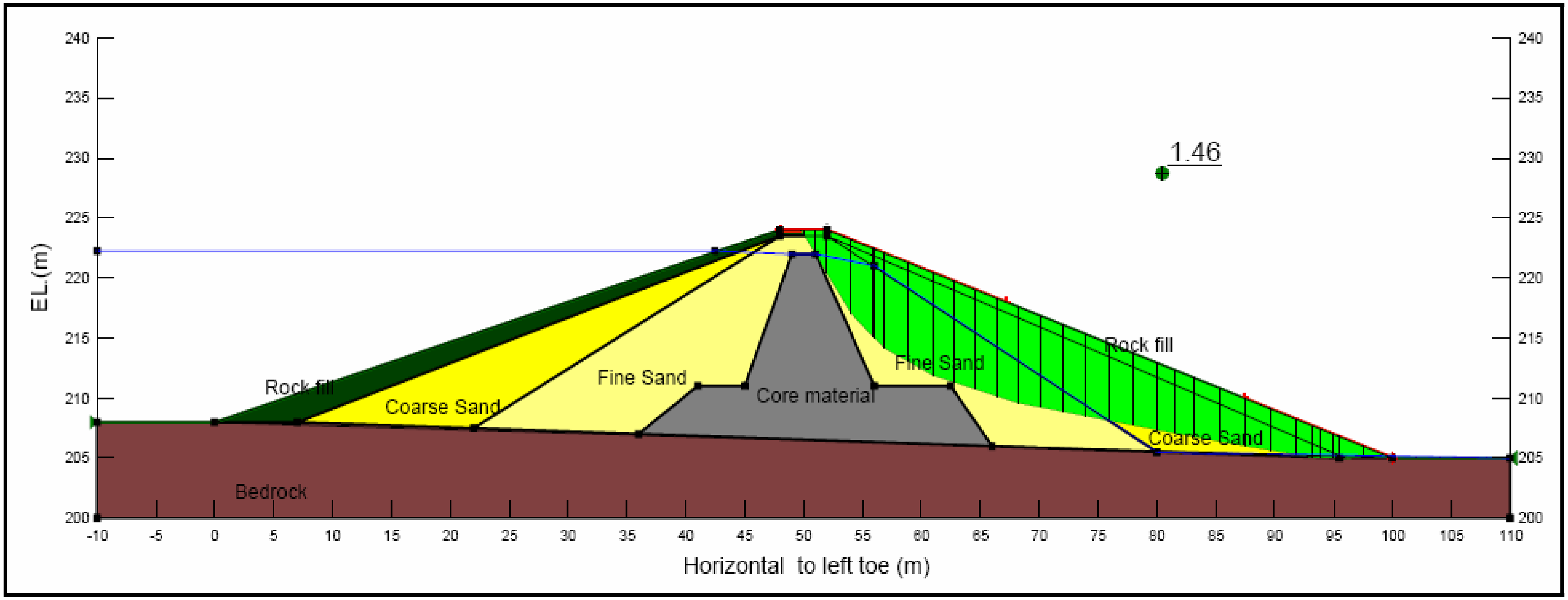



**Figure 6-5**: Snare Rapids Main Dam – Stability (MDE Load Case, FS = 1.46)

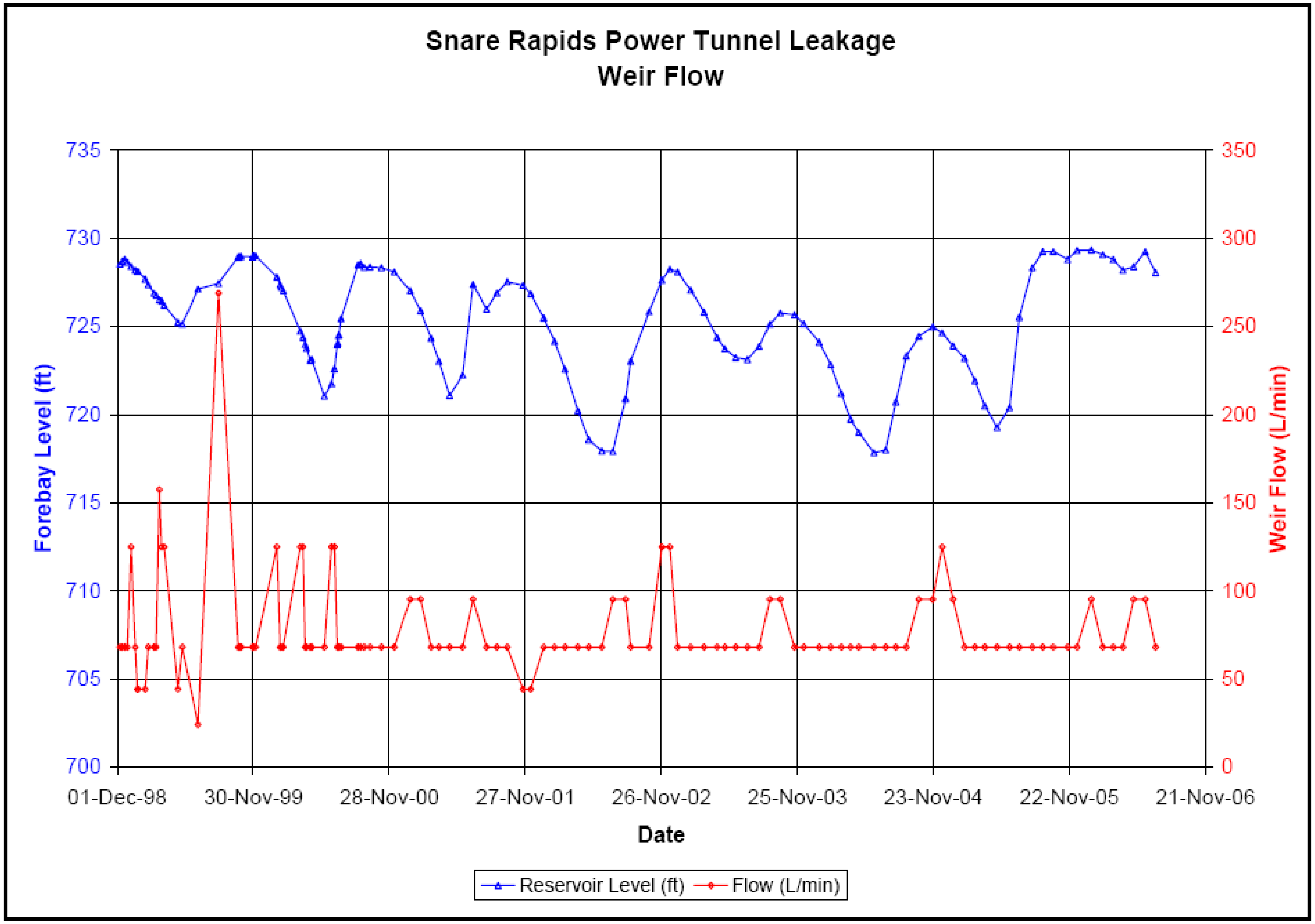



**Figure 6-6**: Snare Rapids Power Tunnel – Weir Flows

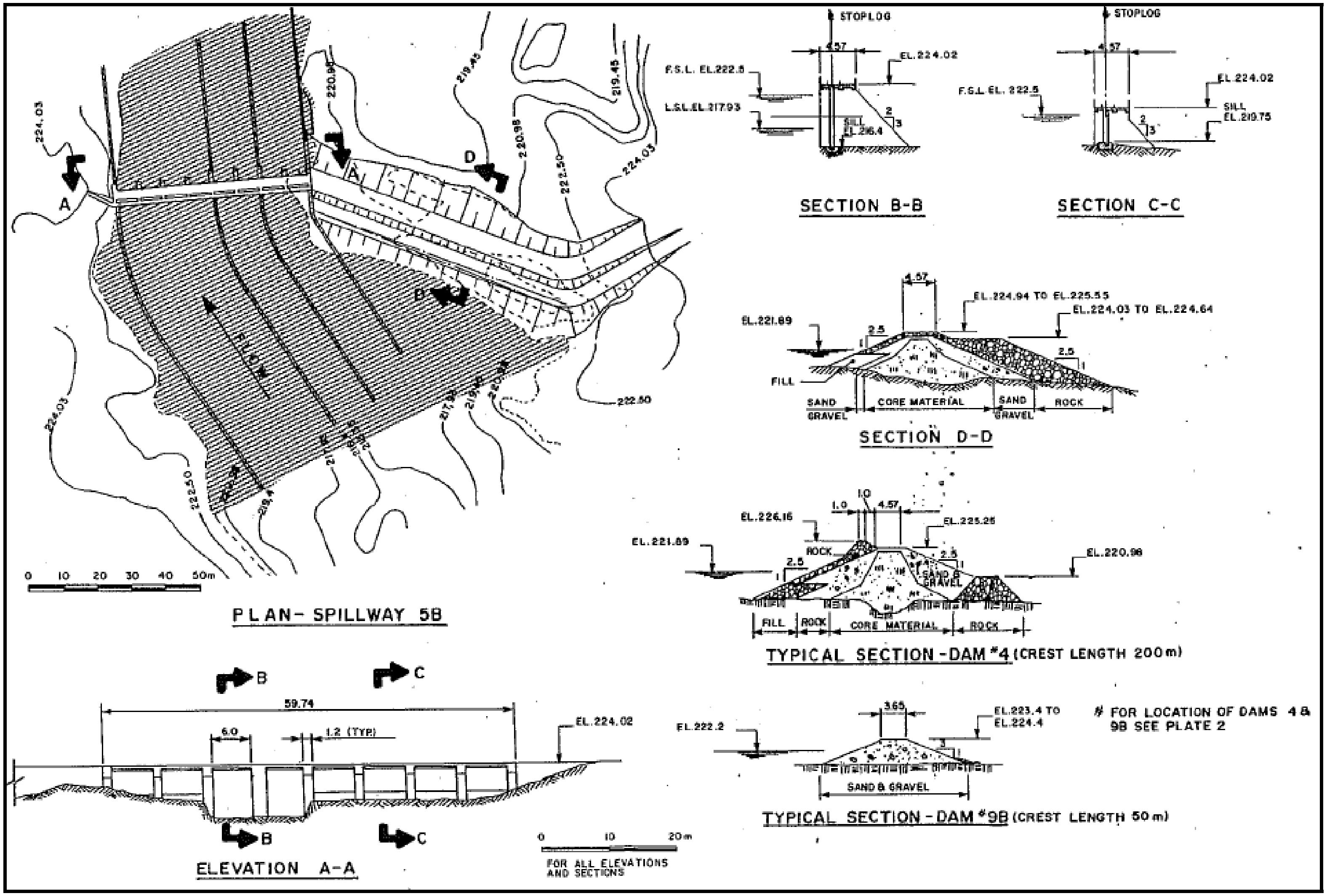



**Figure 6-7**: Spillway 5B, side Dam 5B, 4 and 9B – Layout and Typical Sections

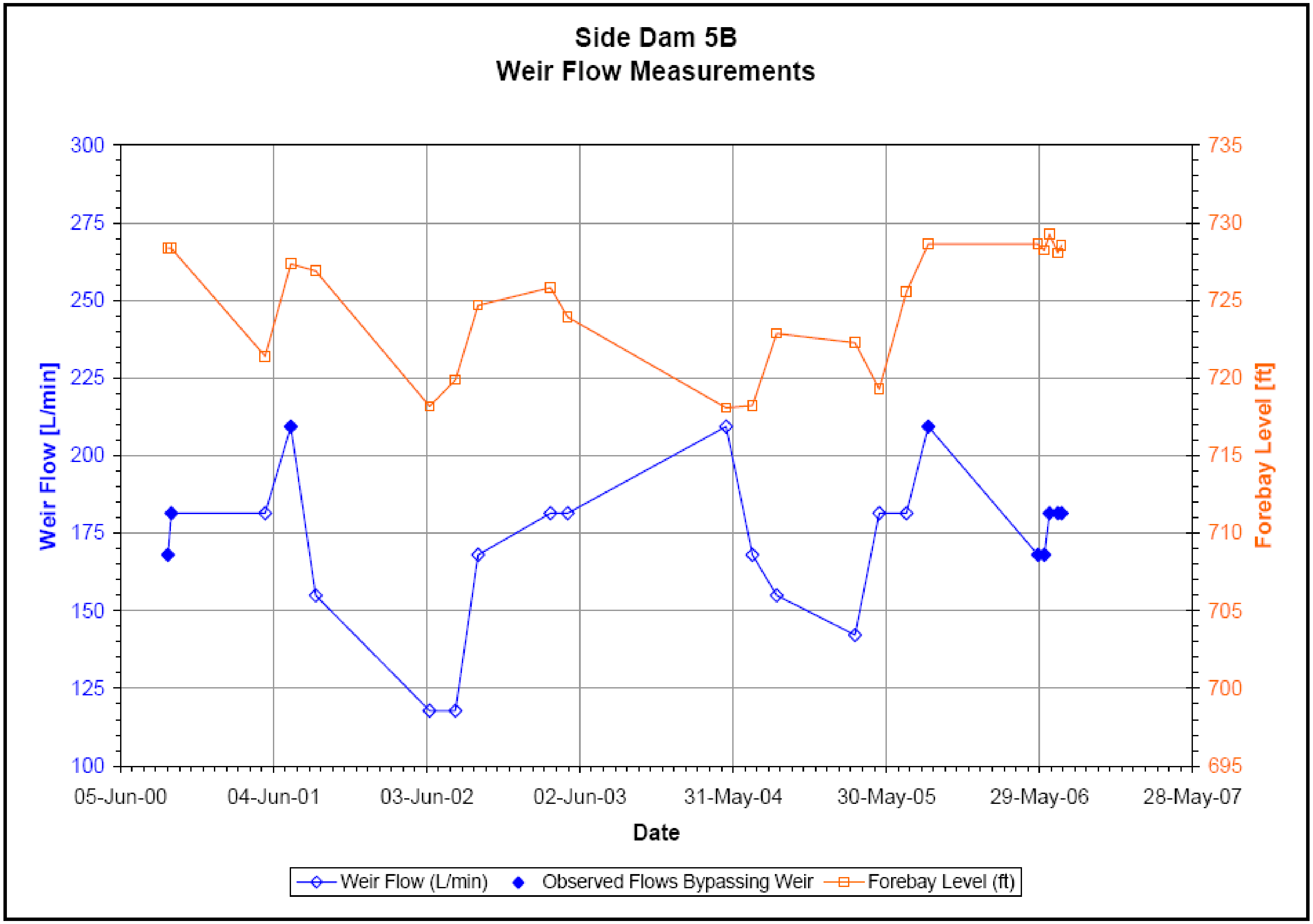



**Figure 6-8**: Saddle Dam 5B – Weir Flow Measurements

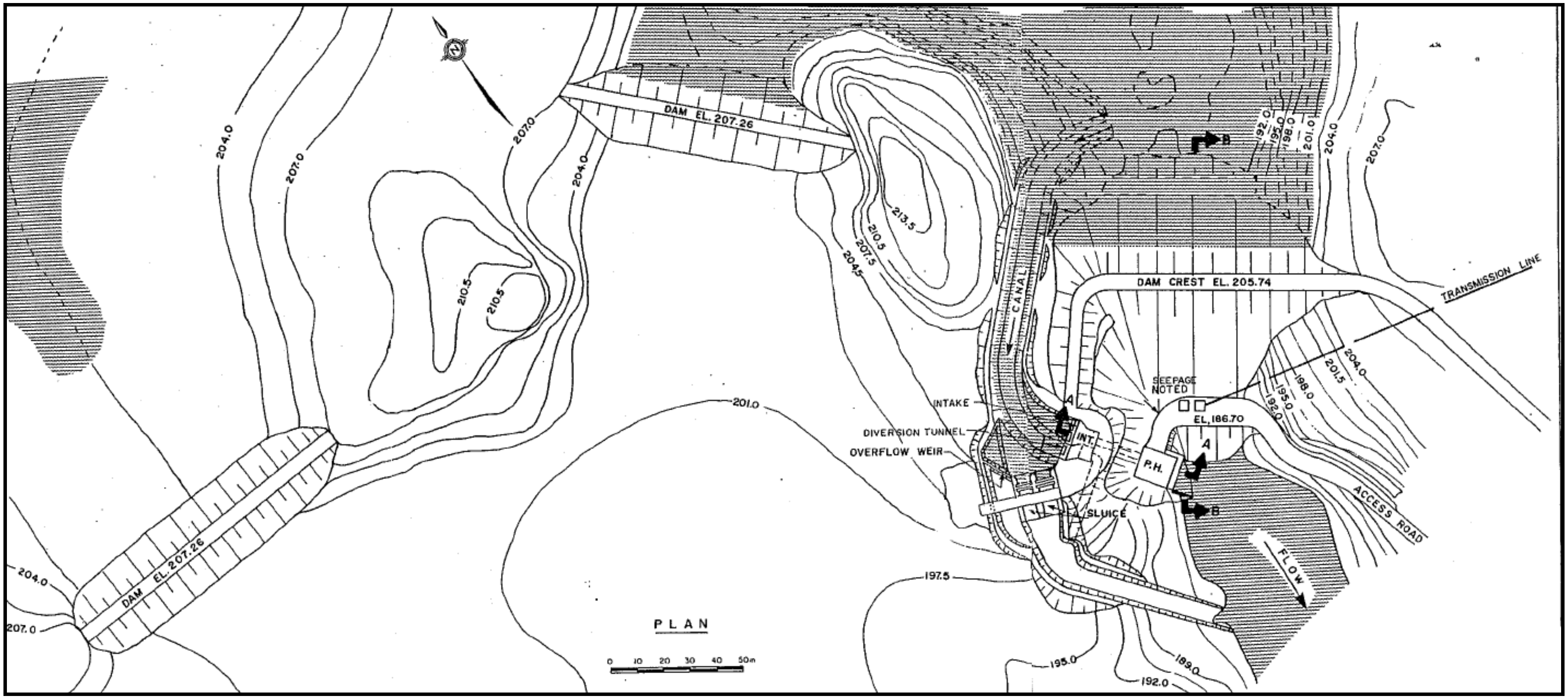



**Figure 7-1**: Snare Falls G.S. – General Arrangement

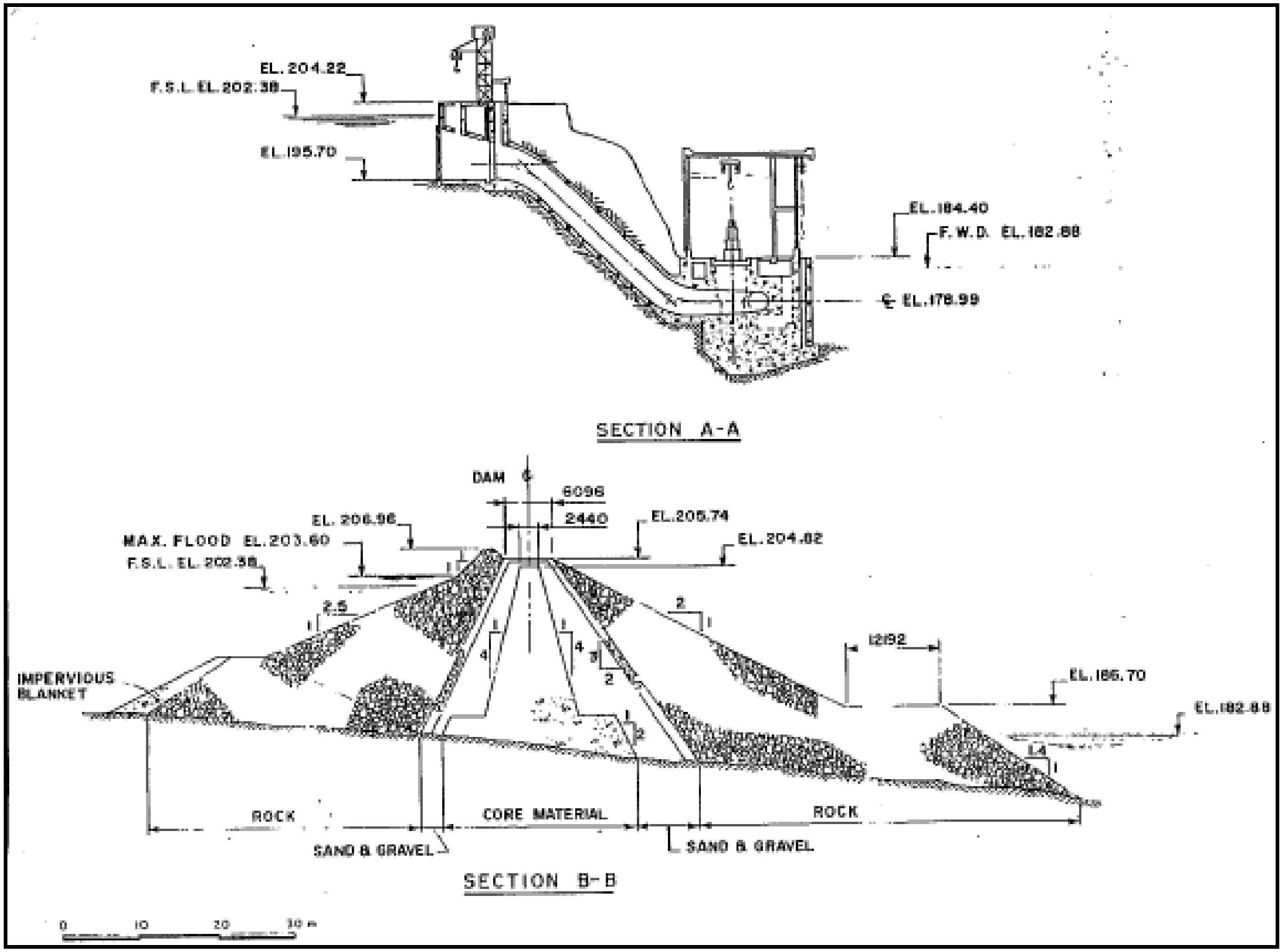



**Figure 7-2**: Snare Falls G.S. – Layout and Typical Sections

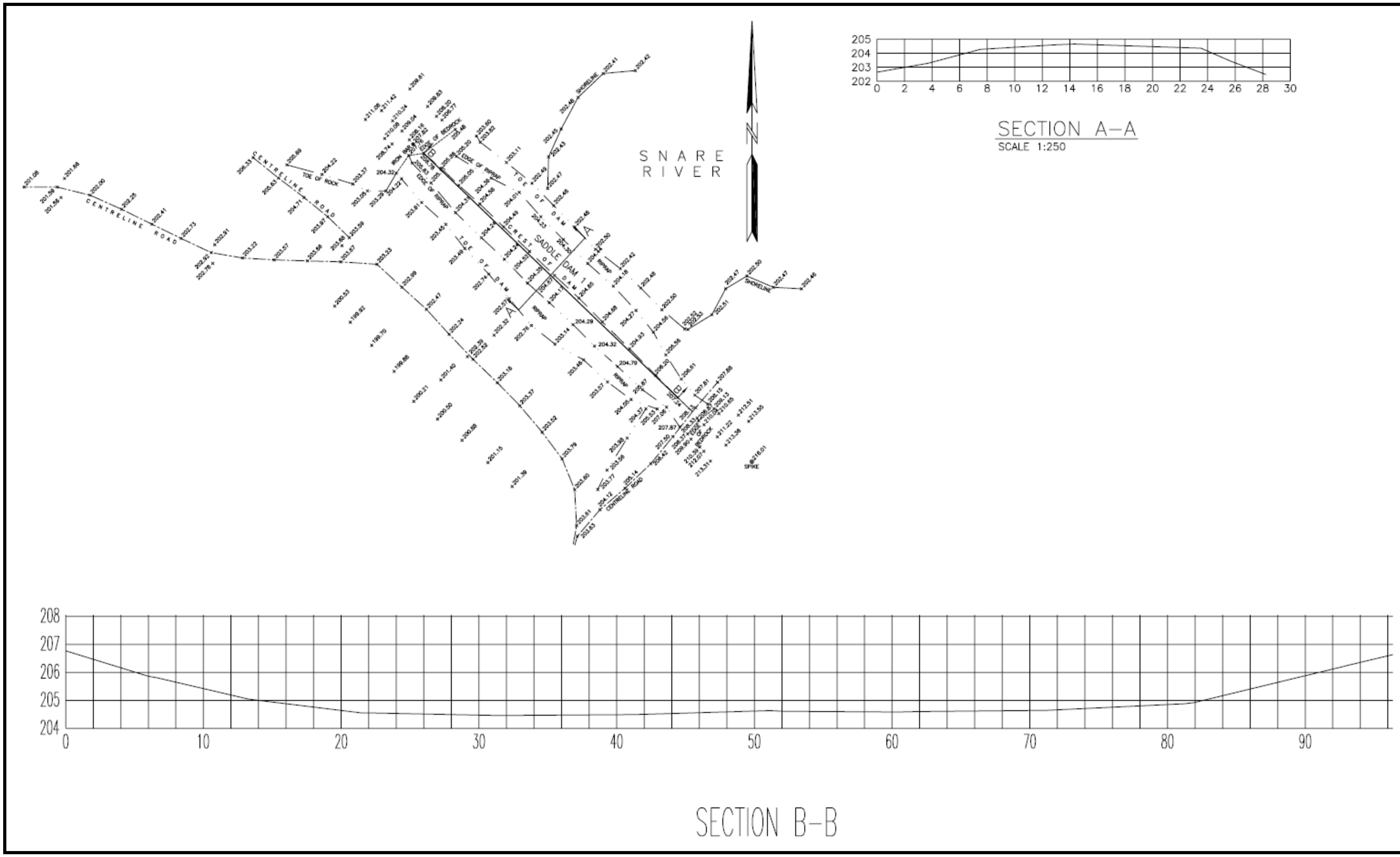



**Figure 7-3**: Snare Falls, Saddle Dam No. 1 – Crest Improvement Survey

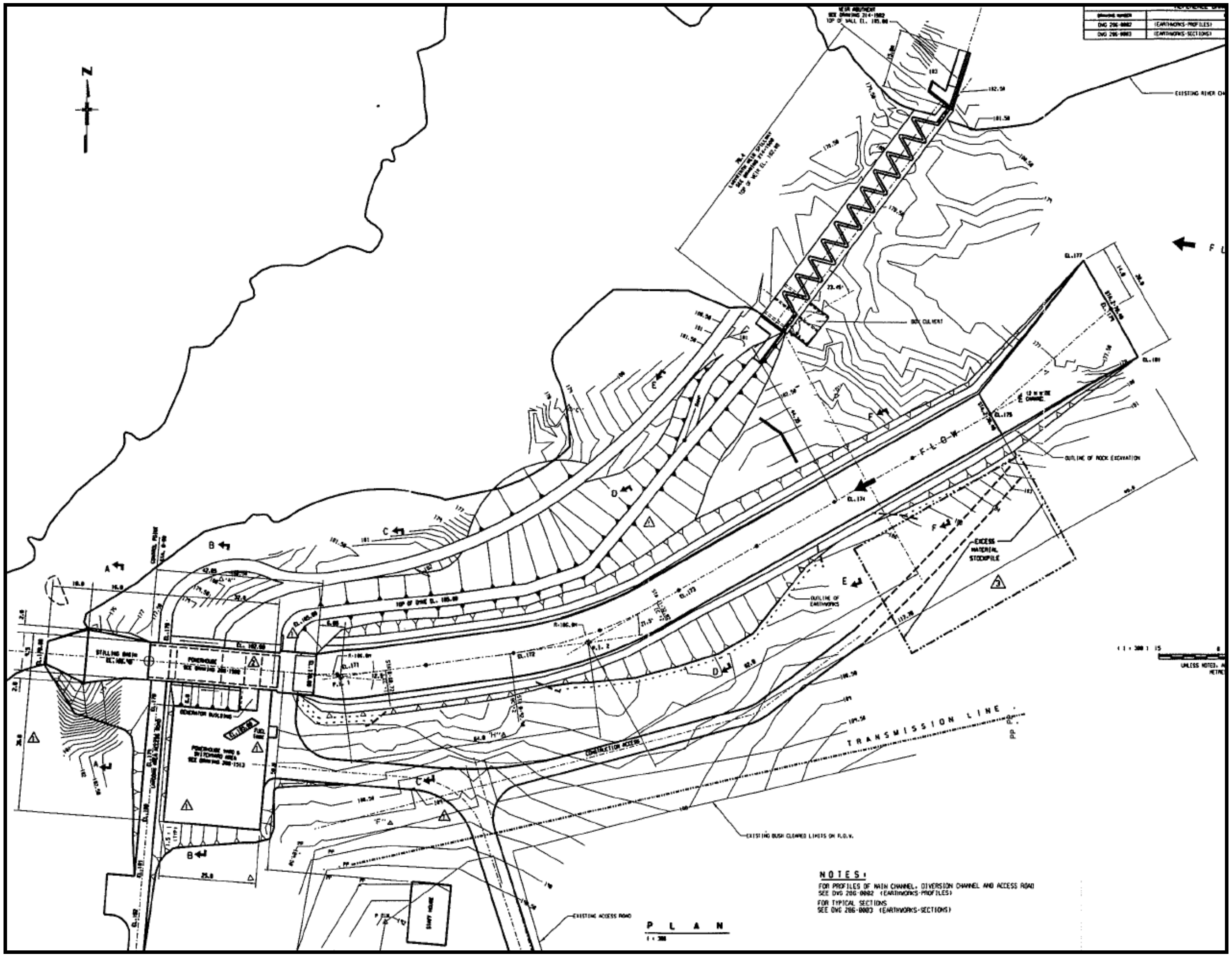



**Figure 8-1**: Snare Cascades G.S. – General Arrangement

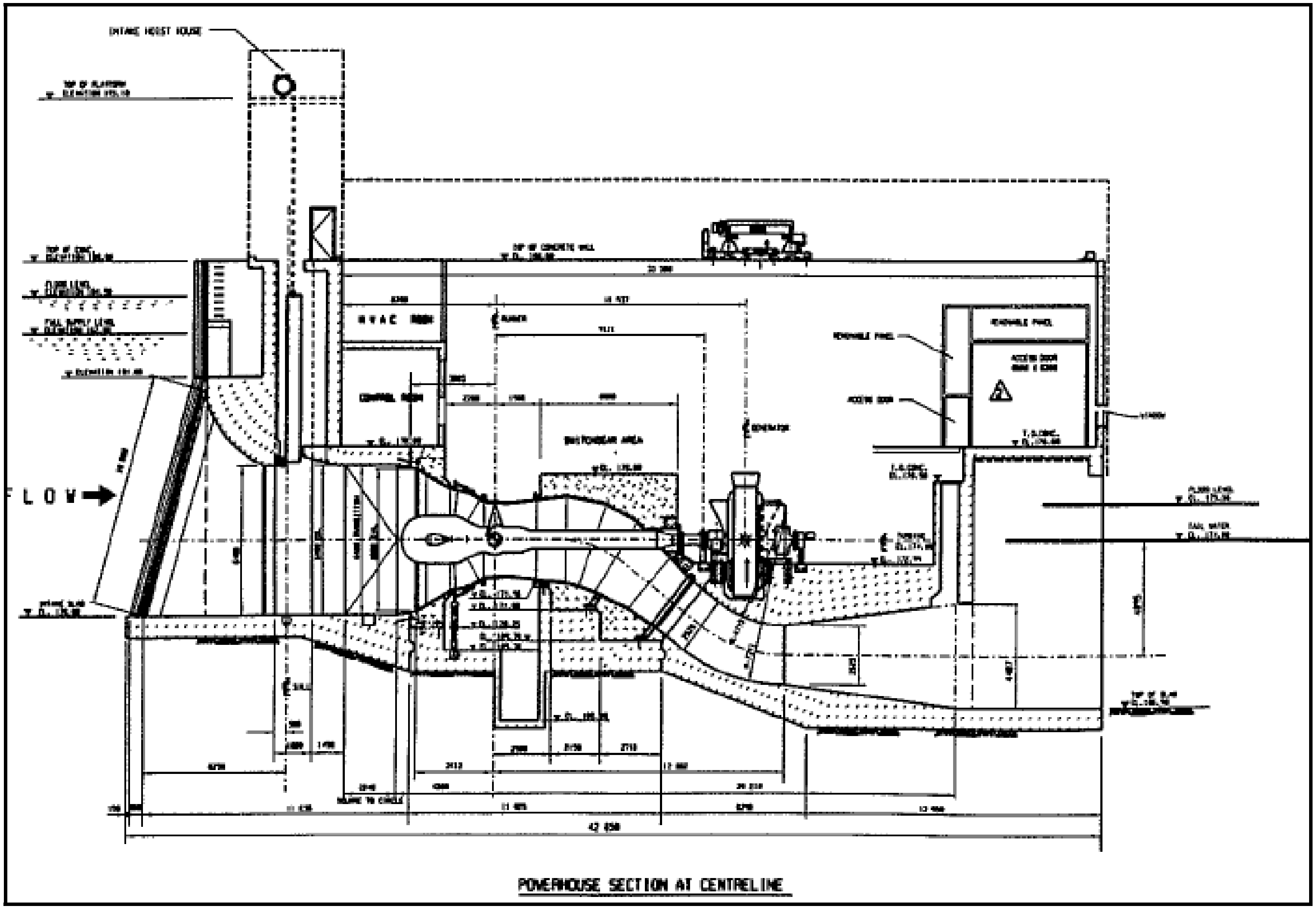



**Figure 8-2**: Snare Cascades G.S. - Intake and Powerhouse Typical Section

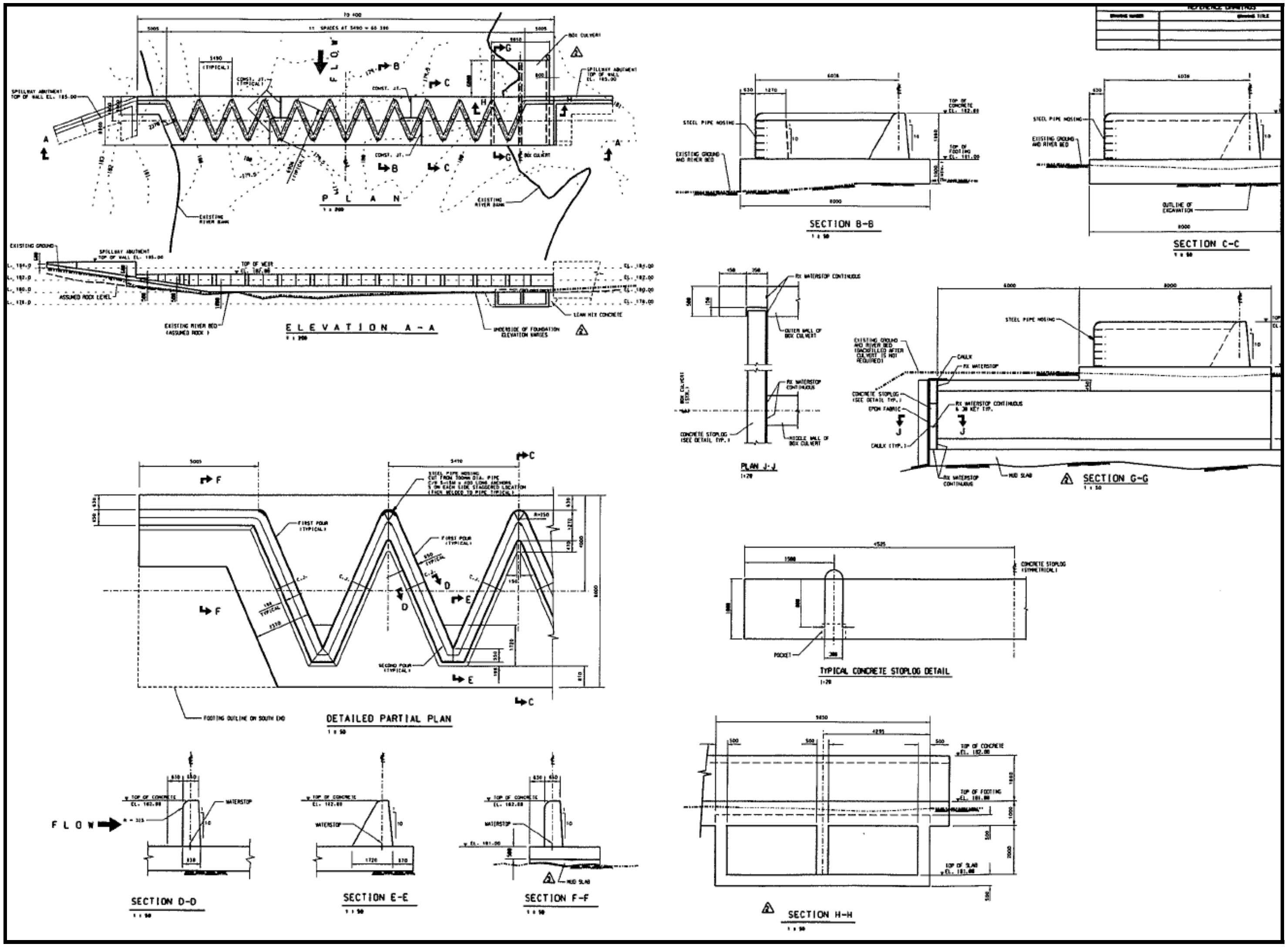



**Figure 8-3**: Snare Cascades G.S. – Labyrinth Spillway Sections and Details

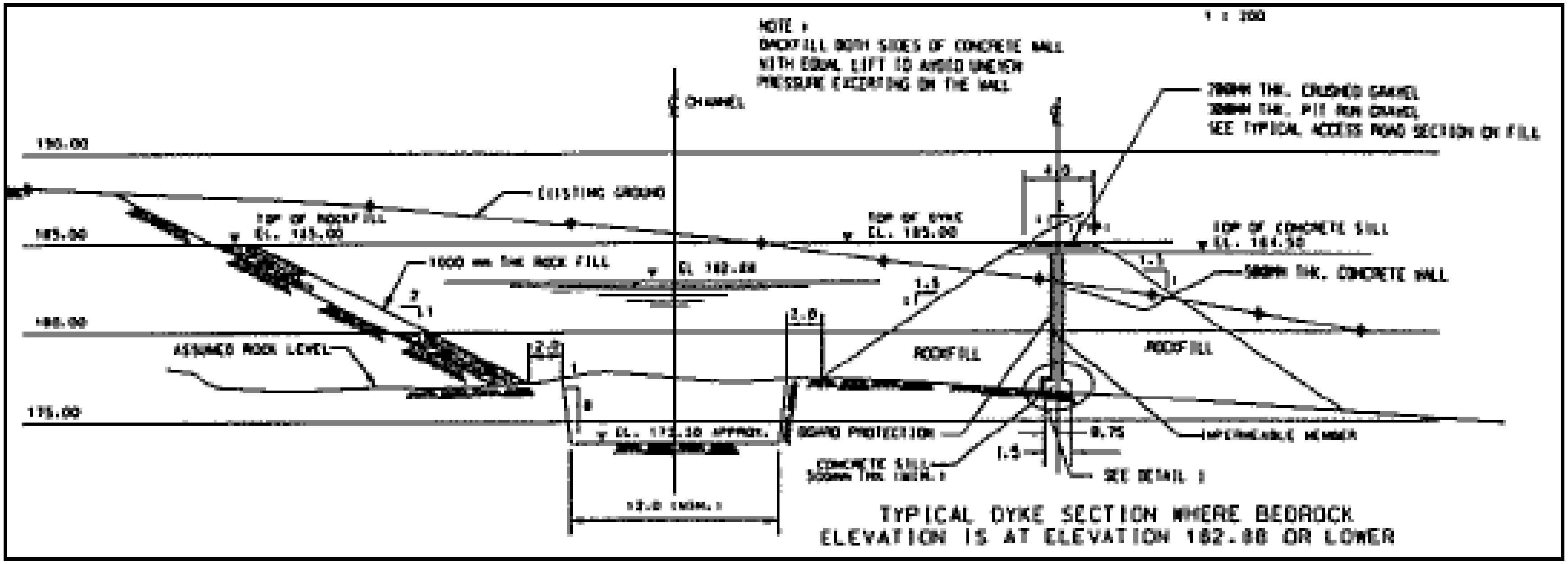



**Figure 8-4**: Snare Cascades G.S. – Approach Channel and Dyke, Sections and Details

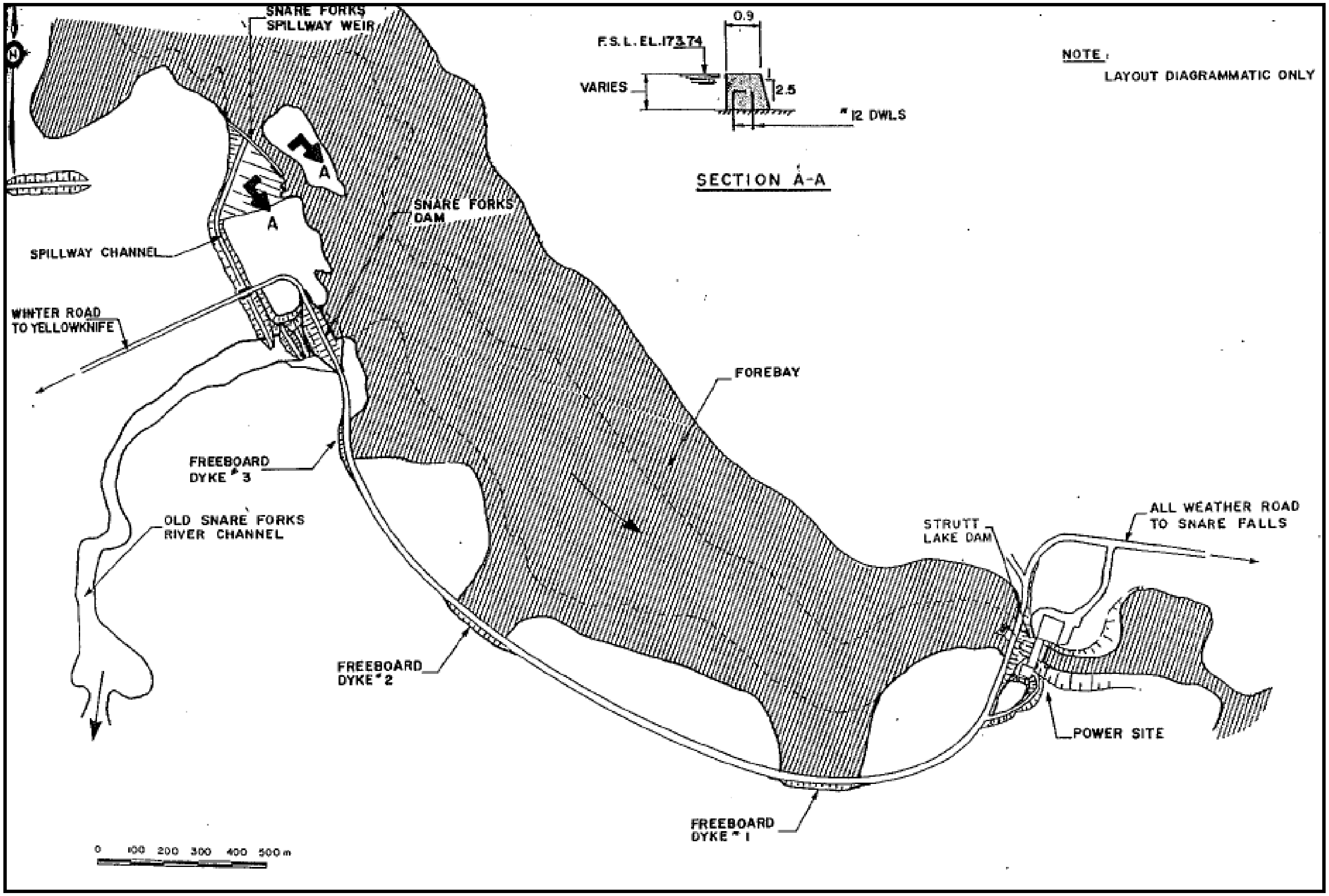



**Figure 9-1**: Snare Forks G.S. – General Arrangement Layout

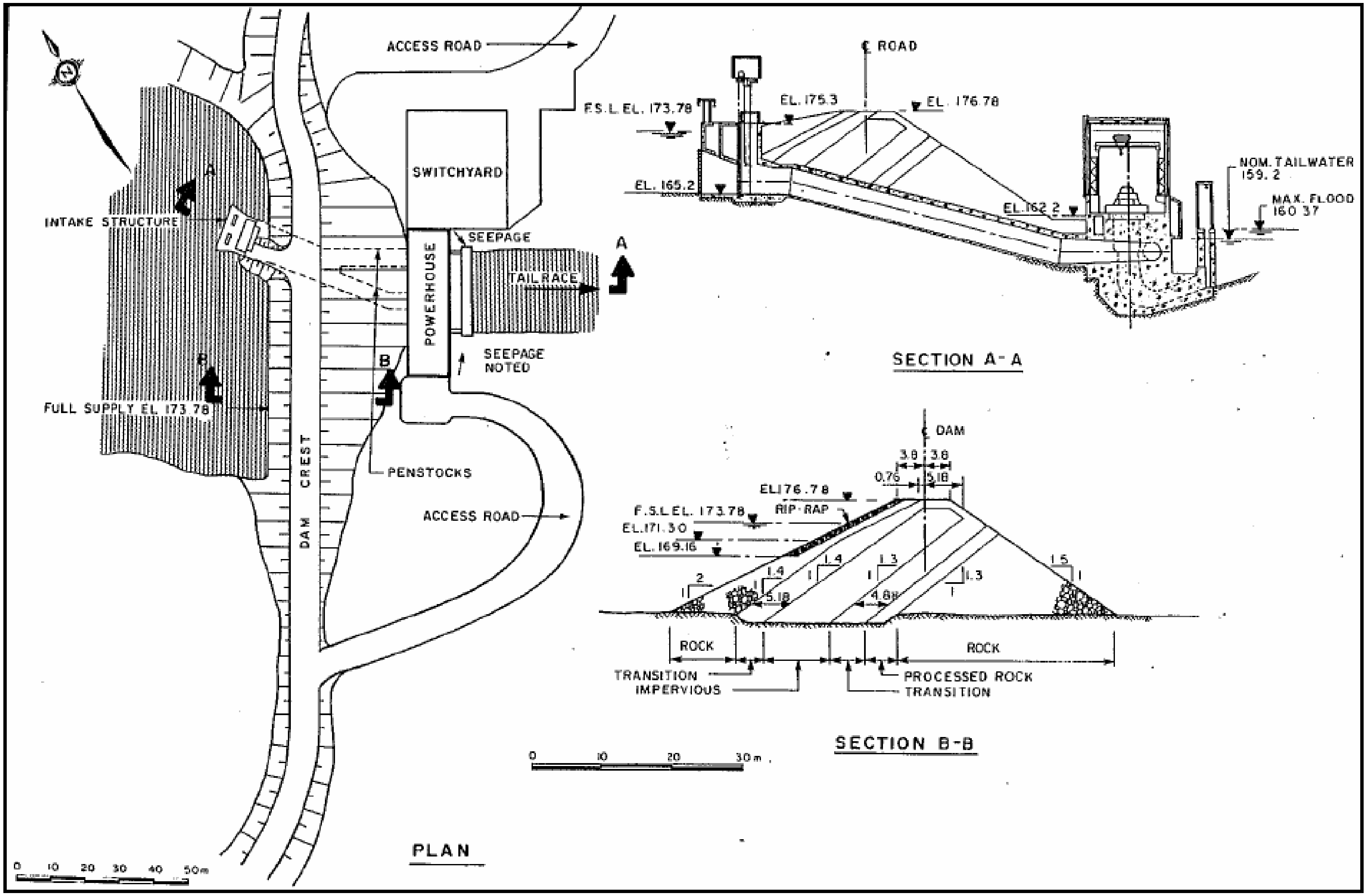



**Figure 9-2**: Snare Forks – Strutt Lake Dam, Intake and Powerhouse

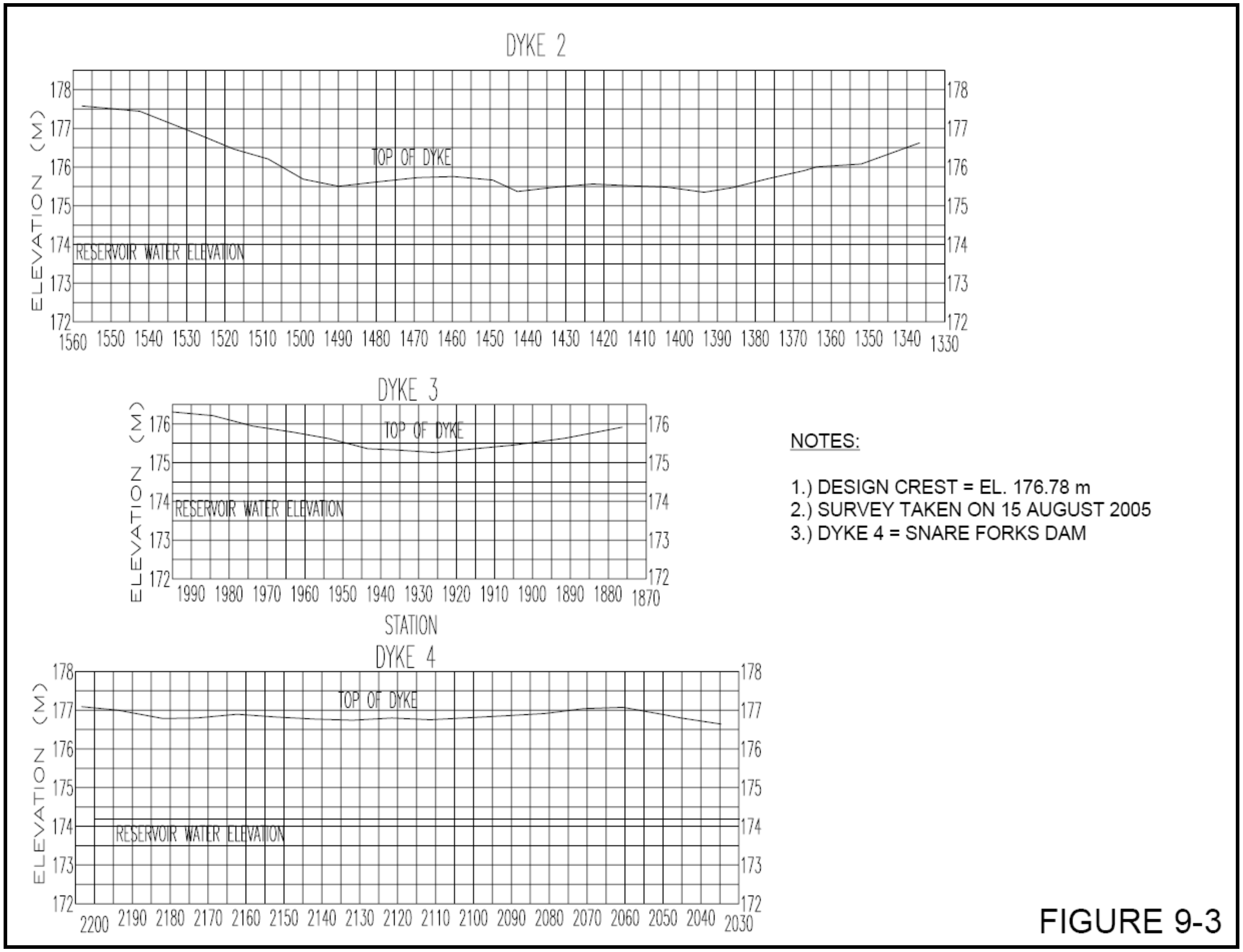



**Figure 9-3**: Snare Forks – 2005 Crest Survey: Dyke 2, 3 and Snare Forks Dam

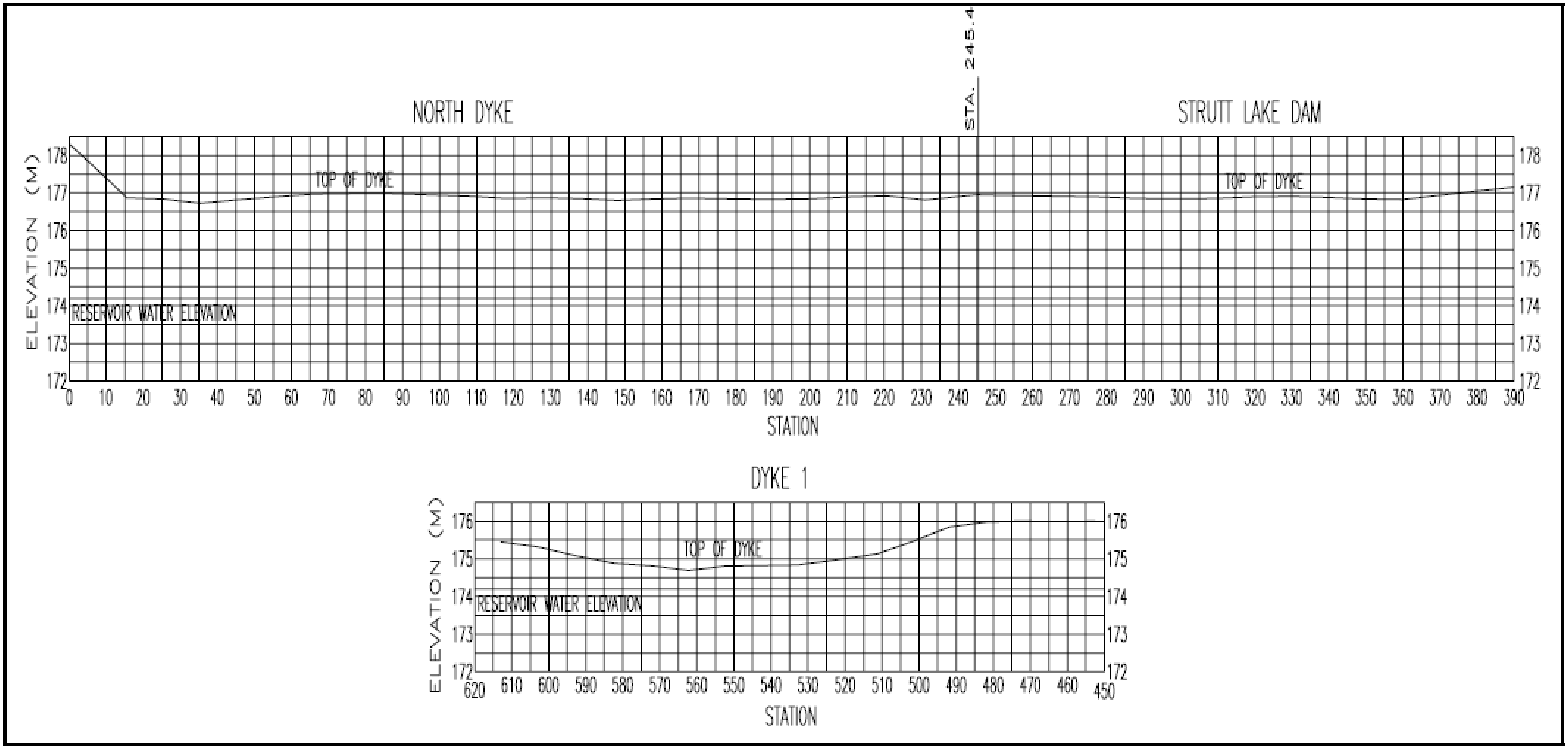



**Figure 9-4**: Snare Forks – 2005 Crest Survey: Dyke 1, North Dyke & Strutt Lake Dam

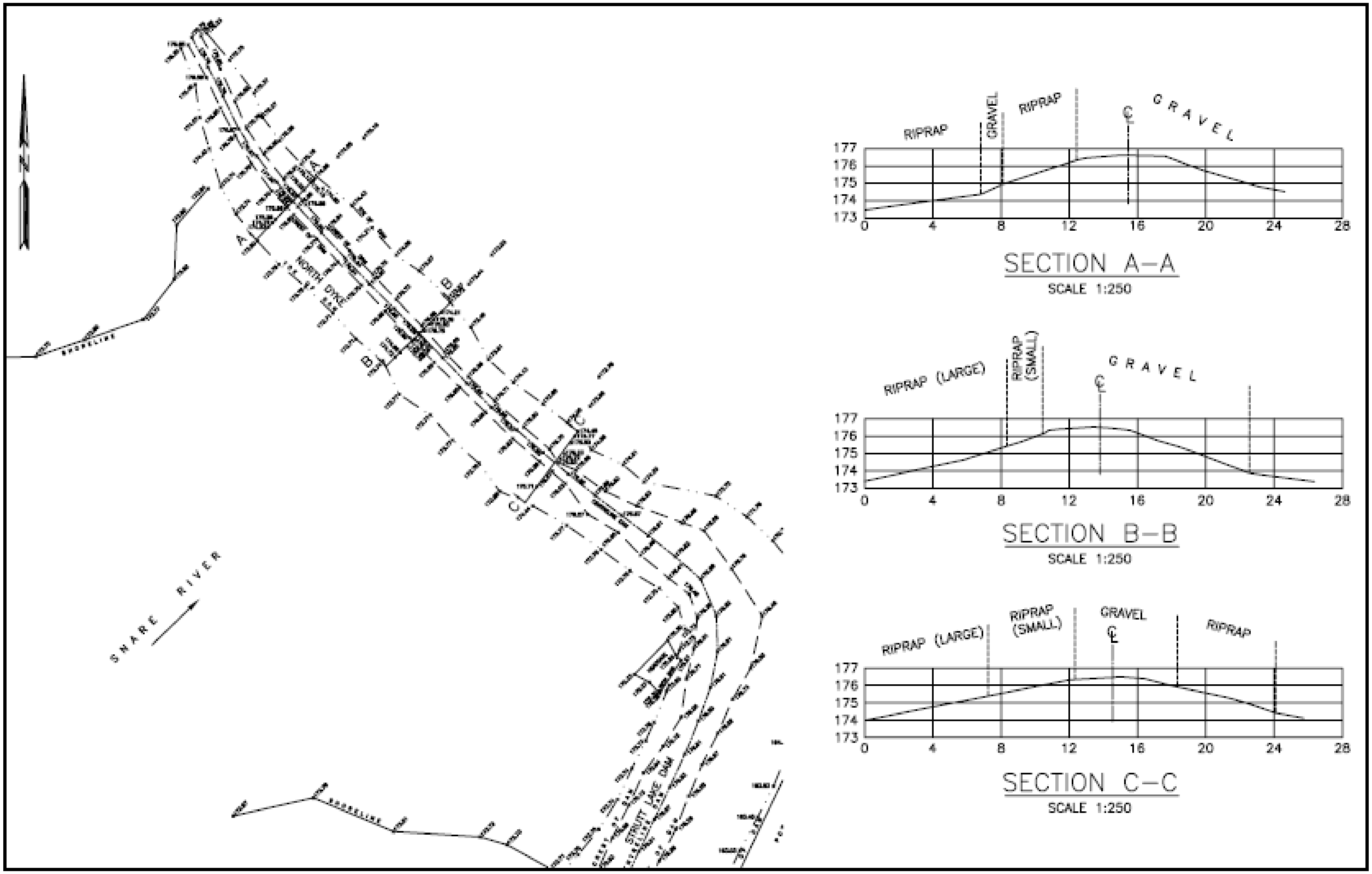



**Figure 9-5**: Snare Forks – 2003 North Dyke Survey: Plan and Typical Sections

# APPENDIX I

## Inspection Check Lists

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 12 July 2006 |
| Feature: | Communications | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Normal Facilities | | |
| • type | S | Phone, radio, internet email |
| • adequacy | S | Good |
| Standby/Emergency Facilities | | |
| • type | S | Satellite phone |
| • adequacy | S | Good |
| Normal Power Supply | | |
| • type | S | AC Station Service |
| • reliability | S | Good |
| Auxiliary/Emergency Power | | |
| • type | S | Diesel |
| • tested | S | Every three months |
| • maintenance | S | Good |
| • tested during inspection? | S | No |
| Remote controls | S | Scada over power line carrier |
| Annunciation/Indication | S | Scada over power line carrier |
| Failure History | S | No problems noted |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 12 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Emergency Preparedness Plan | Reservoir Level: | 728.20 |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | February 2006 |
| Date of Last Revision | S | |
| Current Copy at Dam? | F | Pdf copy available electronically |
| Adequacy of instructions? | S | |
| Are instructions understood? | F | Need Operator review and sign off on file |
| Inundation mapping included? | S | |
| Emergency contact list up to date? | S | |
| Primary/secondary access routes identified? | S | |
| Access during adverse weather | F | Access could be difficult during winter |
| Adequacy of notification charts | S | Up to date and posted |
| Flow chart of actions required in emergency | S | |
| Extent of distribution | U | EPP binder should be in control room |
| Types of tests | U | No tests of EPP system noted |
| Frequency of tests? | U | No tests of EPP system noted |
| Are tests recorded? | U | No |

Notes: Actual implementation of notification procedure for dam breach occurred in June 2006 for saddle dam breach at Snare Forks plant. EPP notification procedures should be tested once a year to verify all contacts are up to date and the contacts know how to respond to notifications.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 12 July 2006 |
| Feature: | Gate | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.20 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | U | Condition unknown |
| Wheels and bearings | U | Condition unknown |
| Roller paths | U | Condition unknown |
| Gate guides | U | Condition unknown |
| Gate / Guide Heating | S | 6 heaters, no problems reported |
| Lifting Lug | U | Sheaves checked when wire rope replaced in 2000 |
| Dogging device | | |
| Seals/leakage | S | Reported to be satisfactory |
| Clearances | S | Condition unknown |
| Heating / weather protection | S | Adequate |
| Other unusual conditions | | Air vents flaps operation satisfactory |

Notes: Divers inspected trashracks in 2006. Reported good condition.

Intake gate not able to be inspected. Gate is submerged and upstream side has not been inspected for many years as it is difficult to remove. Downstream side inspected from penstock annually. Last inspection Aug 05. Recommend remove to inspect upstream side and refurbish within next 2 years.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 12 July 2006 |
| Feature: | Hoist | Weather: | Sunny |
| Detail: | | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Hoist | | |
| • structure | S | Good condition |
| • motor | S | 600V from station service |
| • gearbox | S | no problems reported |
| • fan brake | S | louvers full open for slowest speed |
| • wire rope | S | new in 2000 |
| Hoist weather protection | S | good |
| Operation | S | no problems reported |
| Indicators (mechanical) | S | remote only; no local indication |
| Position Transducers | S | limit switches only |
| Limit Switches | S | rotary, no problems reported |
| Controls | S | gate drops on power loss |
| Operating Procedures | S | posted in hoist house |
| Maintenance Records | S | in Yellowknife |
| Test Records | S | in Yellowknife |
| Other unusual conditions | S | no |

Notes: Closure test 28/6/2006 1 min. 10 seconds. Gate tested annually.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 12 July 2006 |
| Feature: | Standby Power | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | Station service switches to diesel if unit shuts down. |
| Fuel Tank | S | |
| Enclosure | | |
| • venting | S | |
| • exhaust | S | |
| • heating | S | |
| Battery Charging | | |
| Operational Test | | |
| • persons to operate | S | Can be done by one person |
| • ease of operation | S | No problems reported |
| • raise gate | S | By local control panel only |
| • control system | S | No problems reported |
| Emergency Communication System | S | Phone and radio |
| Operating Procedures | S | Manual in control room |
| Maintenance / Test Records | S | In Yellowknife |
| Other unusual conditions | S | No |
| Notes: Intake gate power is on regular station service, not essential service panel. Loss of power to intake causes gate to drop on fan. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 12 July 2006 |
| Feature: | Structure | Weather: | cloudy, some wind |
| Detail: | | Reservoir Level: | 221.96 m (728.20') |
| Inspector: | D. Duivestein | | |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | Concrete sound when impacted with a chipping hammer. |
| General condition | S | |
| Cracks / Spalling | F | See Notes 1, 2 & 3. |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | – | |
| Settlement- particularly fill adjacent to concrete structure | n/a | |
| Trashrack | – | Not visible. |
| Access Bridge | S | Creosoted timber bridge. |
| Concrete Floor | F | Cracks observed. |
| Steel Sheet Insulated Enclosure | F | NWTPC stated they were considering replacing it. |

Notes:

1. The downstream face has large vertical crack commencing at the left hand side air vent. The crack was repaired with a light yellow patching material which has deteriorated and partly spalled. This crack also has a horizontal branch at El 221.28 (726') approx which was below the water level.
2. The downstream left hand side at deck level has spalled and been repaired with the light yellow patching material which has also spalled.
3. The right hand side has a 3 mm wide vertical crack running across the wall at deck level and extending downwards.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 12 July, 2006 |
| Feature: | Abutments | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | Sound, massive, granite abutments. |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | None visible. |
| Slope protection | S | Not required. |
| Vegetation | S | Clear. |
| Other unusual conditions | - | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 12 July, 2006 |
| Feature: | Crest | Weather: | Cloudy and Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | |
| Erosion/ Rutting | S | Well graded. |
| Camber | S | Visually acceptable. |
| Vegetation | S | Some vegetation along shoulders. Remove a part of on-going maintenance. |
| Road surface and Access | S | |
| Barriers/no-post guardrail | S | None provided, but considered acceptable. |
| Burrows | S | |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 12 July, 2006 |
| Feature: | Downstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | N/A | Rockfill. |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | The slope is typically planar and uniform, except behind p/h backwall where slope is locally steeper. |
| Seepage/wet areas (indicate clarity of observed seepage | S | Regular seepage areas still being monitored. No changes since last inspection. |
| Vegetation | F | Some areas small vegetation becoming established. Removal recommended before becoming fully established. |
| Visual condition of Instrumentation (if any) | S | Thermistor string road box and instrument terminal OK. Seepage weirs acceptable. |
| Burrows | – | |
| Other unusual conditions | – | None |

Notes:

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 12 July, 2006 |
| Feature: | Upstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | Some minor areas where slope protection looks marginally “patchy” but satisfactory. |
| Erosion/beaching | S | Surface is uniform and planar for the most part. |
| Settlement/depressions | S | Some areas (just right of Intake) where slope appears slightly flatter. |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | F | Small vegetation is becoming established and should be removed. |
| Debris | F | Some driftwood is getting accumulated and should be removed before it begins to effect the slope protection. |
| Other unusual conditions | – | None. |
| Notes | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 12 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Overcast |
| Detail: | Operating Log | Reservoir Level: | 571.79 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Frequency of entry. | S | As required by events |
| Information recorded: | S | Mostly events and operating information |
| Are changes required? | S | No |
| Other observations | | Log is kept in control room. |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 12 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Overcast |
| Detail: | OM&S Manual | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | December 2005 |
| Date of Last Revision | S | February 2006 |
| Current Copy at Dam? | F | Pdf electronic file available |
| Adequacy of instructions? | S | Yes |
| Are instructions understood? | S | Yes |
| Is flood routing covered? | S | Yes |
| Any special instructions? | S | Station details included |
| Are inspections recorded? | S | Yes |
| Frequency of inspections? | S | Major done annually, regular done daily |
| Are checklists available? | S | Yes |
| Are changes required? | S | No |

Notes:

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Powerhouse | Date: | 12 July 06 |
| Feature: | Overall Structure | Weather: | cloudy, some wind |
| Detail: | | Reservoir Level: | 221.96 m (728.20') |
| Inspector: | D. Duivestein | | P/H in operation |

| Item | Rating | Remarks |
|---|---|---|
| General condition | S | |
| Surface condition | S | |
| Cracks / Spalling | F | See Notes 1 to 5. |
| Corrosion of steel reinforcement | S | None observed. |
| Movement (offsets) | S | |
| Joints | n/a | No expansion/contraction joints observed. |
| Settlement- particularly fill adjacent to concrete structure | S | Not observed. |
| Penstocks – corrosion; signs of distress/distortion | – | Not visible |
| Drains – particularly collecting leakage from penstocks/intakes which may discharge through powerhouse | F | Access hatch to scroll case full of water to ground floor level i.e. up to hatch cover. |
| Tailrace / Draft Tube | F | Stoplog slot for Unit #2 (0.4 MW unit).<br>Spalling and rebar exposed. |
| RC Basement Interior Surfaces | F | Some paint peeling and dampness but no flow observed. To be monitored. |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

| Item | Rating | Remarks |
|---|---|---|
| Notes:<br>1. Downstream wall exterior face has 3 vertical cracks commencing at tailrace deck and running upwards through the rc wall to ground floor level and continuing up the superstructure block work wall following the masonry joints.<br>2. Upstream wall exterior face has similar cracks to the downstream wall.<br>3. NWTPC reported that the exterior walls are 2 wythes thick.<br>4. The cracks were not observed from the interior.<br>5. The superstructure includes structural steel framework and vertical bracing which form a lateral load resisting system hence the superstructure blockwork does not appear to be required to act as shear walls. | | |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 12 July 2006 |
| Feature: | Security | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.20 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Access Roads | S | Site is remote with limited access except in winter. Local roads between the four stations are good. Some access security is in place. Guest house is nearby. |
| Security Measures | S | Vehicle sensor near Snare Forks where winter road enters the area.<br>Station doors generally locked.<br>Restricted areas are fenced. |
| Any Security issues? | | |

Notes:

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 4 | Date: | 12 July, 2006 |
| Feature: | Abutments | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | Sound rock abutments. |
| Cracks/joints/bedding | S | |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | – | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 4 | Date: | 12 July, 2006 |
| Feature: | Crest | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | Undulating surface. |
| Erosion/ Rutting | S/F | Minor erosion gullies in crest surface. |
| Camber | – | Not able to assess due to vegetation. |
| Vegetation | P | Brush removal required. |
| Road surface and Access | S | Boat access during summer. |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 4 | Date: | 12 July, 2006 |
| Feature: | Downstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | N/A | Sand embankment. Rockfill toe requires on-going monitoring. |
| Cracks (length + orientation) | S | |
| Erosion/gullying | F | Sand embankment shows sign of minor erosion and gullying. Monitoring required. |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | Stagnant water at rockfill toe (localised ponding). |
| Vegetation | F | Removal required for assessment. |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | S | |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 4 | Date: | 12 July, 2006 |
| Feature: | Upstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | F | Rockfill variable in size. Some riprap missing. Replace where required. |
| Erosion/beaching | F | Minor erosion and gullying evident. Some beaching towards left abutment. Local replacement of riprap required. |
| Settlement/depressions | F | Same as above. |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | P/F | Extensive vegetation on u/s slope. Must be removed. |
| Debris | F | Minor amounts of debris collected on u/s face. Should be removed at time of brushing.. |
| Other unusual conditions | – | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 5B | Date: | 12 July, 2006 |
| Feature: | Crest | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | Limited assessment due to vegetation. |
| Cracks – longitudinal (length) | S | Limited assessment due to vegetation. |
| Settlement/depressions | F | Crest is slightly low near u/s end survey required. |
| Erosion/ Rutting | S | |
| Camber | – | Not able to evaluate. |
| Vegetation | P | Dense vegetation must be removed to allow effective inspection. |
| Road surface and Access | N/A | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 5B | Date: | 12 July, 2006 |
| Feature: | Downstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | F | Significant seepage at d/s toe measured at weir d/s of toe [1]. |
| Vegetation | F | Extensive vegetation makes evaluation difficult. Removal required. |
| Visual condition of Instrumentation (if any) | F | See note [1]. |
| Burrows | S | |
| Other unusual conditions | S | Timber crib structure currently acceptable, but must be monitored for deterioration. |
| Notes: [1] The leakage collection pond walls must be extended to capture all leakage. The notch slot should be improved to improve reading accuracy. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 5B | Date: | 12 July 2006 |
| Feature: | Upstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S/F | Some areas where larger particles of riprap are lacking. Monitoring and local riprap augmentation required. |
| Erosion/beaching | S | |
| Settlement/depressions | S/F | Some areas where minor depression obvious. On-going monitoring. |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | F | Extensive vegetation on slope should be removed. |
| Debris | S | |
| Other unusual conditions | – | None |
| Notes: Limited fetch results in u/s slopes protection issues being non-critical. | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 9B | Date: | 12 July, 2006 |
| Feature: | Abutments | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | S | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 9B | Date: | 12 July, 2006 |
| Feature: | Crest | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | F | Central portion noticeably lower. Survey required to confirm design level is met. |
| Erosion/ Rutting | S | |
| Camber | F | Central portion noticeably lower. Survey required [(1)]. |
| Vegetation | S | |
| Road surface and Access | N/A | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | |

Notes: [(1)] Dam has been topped up previously.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 9B | Date: | 12 July, 2006 |
| Feature: | Downstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | N/A | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | F | Ponded, stagnant water at toe (local). On-going monitoring required. |
| Vegetation | F | |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Side Dam 9B | Date: | 12 July, 2006 |
| Feature: | Upstream Slope | Weather: | Cloudy & Cool |
| Detail: | | Reservoir Level: | 728.20 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | N/A | None provided. |
| Erosion/beaching | F | Minor erosion gullying evident. Monitor for deterioration. |
| Settlement/depressions | F | As above. |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | Minor vegetation should be removed. |
| Debris | F | Debris raft should be removed. |
| Other unusual conditions | – | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway 5B | Date: | 12 July 2006 |
| Feature: | Hoist | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Log Lifter structure | | |
| • connections | S | Loglifter structural steel frame in good condition |
| • upper guides | S | |
| • structural | S | |
| • screw hoist support | S | |
| • tower base anchorage | S | |
| Log Lifter Bridge | S | Bridge frame of loglifter in good condition |
| • connections | S | |
| • structural | S | |
| • hoist anchorage | S | |
| Log Lifter Hoist House | S | Hoist house in good condition |
| • condition | S | |
| • openings | S | |
| • lighting | S | |
| • heating | S | |
| • access | S | |
| Log Lifter Hoist | S | Hoist components in good condition |
| • motor | S | |
| • gearbox | S | |

Rating

S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| Item | Rating | Remarks |
|---|---|---|
| Hoist weather protection | S | Enclosed hoist house |
| Operation | S | No problems reported |
| Indicators (mechanical) | | Local only |
| Position Transducers | | none |
| Limit Switches | S | end of travel limit switches |
| Controls | S | local only; reported fully functional |
| Operating Procedures | S | copy in hoisthouse |
| Maintenance Records | S | in Yellowknife |
| Test Records | S | in Yellowknife |
| Other unusual conditions | S | no |

Notes: Standard Kennedy log lifter with 2 spears. Main power is from station service (600 VAC electric motor); backups are gas engine and manual crank.

Lifter will reach bottom logs in all slots. All logs taken out in 1995, 10 logs replaced in 2001, 25 logs replaced in 2006.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway 5B | Date: | 12 July 2006 |
| Feature: | Standby Power | Weather: | Overcast |
| Detail: | | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | Manual clutch between normal electric motor and backup gas engine. Second manual crank backup. |
| Fuel Tank | S | |
| Enclosure | S | |
| • venting | S | |
| • exhaust | S | |
| • heating | S | |
| Battery Charging | | |
| Operational Test | | |
| • persons to operate | S | 2 or 3 |
| • ease of operation | S | |
| • raise stoplogs | S | |
| • control system | S | Local control only |
| Emergency Communication System | S | |
| Operating Procedures | S | Operating manual in log lifter house |
| Maintenance / Test Records | S | In Yellowknife |
| Other unusual conditions | | |
| Notes: main power is 600 VAC supply via pole line from station service, backup power is gas engine, and second backup is hand or portable tool crank. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway 5B | Date: | 12 July 2006 |
| Feature: | Stoplogs | Weather: | Overcast |
| Detail: | 8 bay stoplog structure | Reservoir Level: | 728.2 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| General Condition | S | Good |
| Stoplog Structure | S | Good |
| Stoplog Seals | S | Good |
| Stoplog Slots / Guides | F | Steel liner damage in one location |
| Stoplog handler | | |
| • latching mechanism | S | Not difficult to move |
| • spears | S | Good condition |
| Operating Procedures | S | Copy in the loglifter hoist house |
| Maintenance Records | S | In Yellowknife |
| Operating Records | S | In Yellowknife |
| Test Records | S | |
| Other unusual conditions | S | None: No problems reported about Operation<br>Normal operation is only 1 – 2 slots; All logs were removed in 1995. 10 logs were replaced in 2001 and 25 are being replaced in 2006. |

Notes: Two problems noted: Spillway 5B can not pass the inflow design flood and normal access is by boat. Another spillway may be required to provide flood routing.

A land route for a truck or ATV should be developed to assure access during bad weather.

Rating

S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway 5B | Date: | 12 July 06 |
| Feature: | Structure | Weather: | cloudy, some wind |
| Detail: | RC Structure & Timber Crib | Reservoir Level: | 221.96 m (728.20') |
| Inspector: | D. Duivestein | | #3 open & discharging |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | See Note 1. |
| General condition | S | Concrete appeared sound when impacted with a light chipping hammer. |
| Cracks / Spalling in Spillway | P | Spillway piers for #3 and #4 have major vertical cracks and potential major spalling along the heated stoplog embeds. (gains). |
| | S | Spillway piers for # 1, 2, 5, 6, 7 & 8. |
| Cracks / Spalling in right hand side upstream retaining wall | F | Vertical cracks, some right through the wall, efflorescence observed. To be monitored. |
| Corrosion of steel reinforcement | S | None observed. |
| Movement (offsets) | F | Right hand side upstream retaining wall has 20 mm offset to right hand side at joint with spillway at deck level and this offset increases with depth. To be monitored. |
| Joints | F | Some sliding joints of decks on piers are malfunctioning e.g #2 spillway right hand side displays a spalled bearing surface.<br>To be monitored. |
| Settlement- particularly fill adjacent to concrete structure | S | None observed. |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Rapids Development**

| Item | Rating | Remarks |
|---|---|---|
| Abutments | S | Some vertical cracks. |
| Timber Crib Wall | F | Most accessible timber is sound but some soft zones encountered. To be monitored. |
| Spillway RC Deck | F | Cracks observed especially adjacent to deck expansion joints in the narrow concrete strip between the gate guide embeds (gains) and the main deck slab. See e.g. #4 left hand side to #5 right hand side. Some minor repairs have been previously made some of which have deteriorated. |
| Other unusual conditions | P | Unit #4 left hand side steel embed (stoplog guide). A 1 cm bulge and corresponding tear in the embed was observed approximately 2 m below deck level. The bulge will prevent stoplog sealing and will possibly cause stoplog jamming. |

Notes:

1. Some minor erosion of pier walls below high waterline and slab at base of stoplogs. Appearance generally a fine aggregate type finish and the more severe areas display a coarse aggregate type finish such as the right hand side pier of spillway #4.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Communications | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Normal Facilities | | |
| • type | S | Phone, radio, internet email |
| • adequacy | S | Good |
| Standby/Emergency Facilities | | |
| • type | S | Satellite phone |
| • adequacy | S | Good |
| Normal Power Supply | | |
| • type | S | AC Station Service |
| • reliability | S | Good |
| Auxiliary/Emergency Power | S | No diesel at this station; relies on rural station service supply from other stations |
| • type | S | |
| • tested | S | |
| • maintenance | S | |
| • tested during inspection? | S | |
| Remote controls | S | Scada over power line carrier |
| Annunciation/Indication | S | Scada over power line carrier |
| Failure History | S | No problems noted |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Emergency Preparedness Plan | Reservoir Level: | 663.61 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | February 2006 combined manual |
| Date of Last Revision | S | |
| Current Copy at Dam? | F | Pdf copy available; hardcopy to be done. |
| Adequacy of instructions? | S | |
| Are instructions understood? | F | |
| Inundation mapping included? | S | |
| Emergency contact list up to date? | S | June 2006 |
| Primary/secondary access routes identified? | S | |
| Access during adverse weather | F | Winter conditions may delay access |
| Adequacy of notification charts | S | |
| Flow chart of actions required in emergency | S | |
| Extent of distribution | F | EPP binder should be in control room EPP |
| Types of tests | P | No tests of EPP system noted |
| Frequency of tests? | P | None |
| Are tests recorded? | P | No |
| Are changes required? | F | yes |

Notes: Actual implementation of notification procedure for dam breach occurred in June 2006 for saddle dam breach at Snare Forks plant. EPP notification procedures should be tested once a year to verify all contacts are up to date and the contacts know how to respond to notifications.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Gate & Stoplogs | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | S | Intake Gate underwater and not observed. Reported to be in good condition |
| Wheels and bearings | S | No operating problems reported |
| Roller paths | S | Not observed, Inspection report requested |
| Gate guides | S | Not observed, Inspection report requested |
| Gate / Guide Heating | S | Gate slot heated, gate submerged. |
| Lifting Lug | S | Slight rust on sheaves; icing reported |
| Dogging device | S | |
| Seals/leakage | S | Reported to be good |
| Clearances | S | Reported to be good |
| Stoplog Structure | S | |
| Stoplog Seals | S | Wood seas in good condition |
| Stoplog Slots / Guides | S | good |
| Stoplog Follower | | |
| • latching mechanism | S | good |
| • roller guides | S | good |

Notes: Steel stoplogs with wood seals. Inspected regularly but not used recently. Stoplogs used for maintenance only. Installed manually.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Hoist | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Hoist | S | |
| • structure | S | good |
| • motor | S | 600 VAC |
| • gearbox | S | good |
| • fan brake | S | good |
| • wire rope | S | Replaced in 2003 |
| Hoist weather protection | S | good |
| Operation | S | local and remote checked annually |
| Indicators (mechanical) | S | on hoist |
| Position Transducers | S | remote position in control room |
| Limit Switches | S | on hoist, good condition |
| Controls | S | raise is local only, lower is local and remote |
| Operating Procedures | S | O&M manual in control room. |
| Maintenance Records | S | In Yellowknife |
| Test Records | S | In Yellowknife |
| Other unusual conditions | S | No |

Notes: Gate closure tested once a year.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Standby Power | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | 600 V Station Service supply from powerhouse |
| Enclosure<br>• venting<br>• exhaust<br>• heating | S | |
| Battery Charging | | Station DC system (battery) supplies gate control circuits and brake holding solenoid. |
| Operational Test<br>• persons to operate<br>• ease of operation<br>• raise gate<br>• control system | S | Radio only; no phone at intake. |
| Emergency Communication System | S | Posted in intake house and in control room |
| Operating Procedures | S | Gate annually tested; last test May 2005. |
| Maintenance / Test Records | S | Located in Yellowknife |
| Other unusual conditions | | |

Notes: Loss of AC and DC power to the gate causes the gate to close by gravity with speed regulated by fan brake. Power supply to intake is 600VAC and 120 VDC.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 06 |
| Feature: | Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 202.27 m (663.61') |
| Inspector: | D. Duivestein | | |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | |
| General condition | S | |
| Cracks / Spalling | S | |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | | |
| Settlement- particularly fill adjacent to concrete structure | S | |
| Other unusual conditions | S | |
| Steel superstructure for hoist | F | Requires painting. |

Notes:

1. Basically only the deck and steel superstructure were visible.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 13 July, 2006 |
| Feature: | Abutments | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | |
| Erosion/ Rutting | S | Minor tire rutting @ 90° corner. |
| Camber | S | |
| Vegetation | F | Vegetarian along crest becoming re-established. Remove as part of on-going maintenance. |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | Typically none provided. At intake channel OK. |
| Burrows | N/A | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | Minor seepage from sub-horizontal jointing in right abutment (behind p/h wall). <0.5L/min. |
| Vegetation | F | Vegetation at right abutment should be cleared as part of on-going maintenance. |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | N/A | |
| Other unusual conditions | - | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Main Dam | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | Face generally planar. Riprap is well graded in good condition. Angular rock, well interlocked. |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | F | Vegetation becoming established at water line. Recommend removal. |
| Debris | F | Only minor collections of woody debris. Removal to prevent riprap dislodging. |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Log | Reservoir Level: | 663.61 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Frequency of entry. | S | As required by events |
| Information recorded: | S | Mostly events and operating information |
| Are changes required? | S | No |
| Other observations | | Log is kept in control room. |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Orders | Reservoir Level: | 663.61 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | U | No assembled binder of station operating orders. Some information contained in EPP and some on posted instruction sheets in the plant. |
| Date of Last Revision | | |
| Current Copy at Dam? | U | |
| Adequacy of instructions? | U | |
| Are instructions understood? | F | Yes |
| Reporting requirements? | S | Operating data reporting is adequate |
| Any special instructions? | S | No |
| Is flood routing covered? | U | No |
| Is special surveillance covered? | S | No |
| Are changes required? | U | Yes |
| Other observations | | |

Notes: A binder of operating orders should be assembled and located in each powerhouse control room and operator's housing.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | OM&S Manual | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | December 2005 combined manual for Snare system of plants |
| Date of Last Revision | S | February 2006 |
| Current Copy at Dam? | S | Available in electronic PDF format |
| Adequacy of instructions? | S | Yes |
| Are instructions understood? | S | Operators need to become familiar with manual |
| Is flood routing covered? | S | Yes |
| Any special instructions? | S | Site specific instructions included |
| Are inspections recorded? | S | Yes |
| Frequency of inspections? | S | Major annual inspection |
| Are checklists available? | S | Yes – in OMS manual |
| Are changes required? | S | No |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Powerhouse | Date: | 13 July 06 |
| Feature: | Overall Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 202.27 m (663.61’) |
| Inspector: | D. Duivestein | | P/H in operation |

| Item | Rating | Remarks |
|---|---|---|
| General condition | S | |
| Surface condition | S | |
| Cracks / Spalling | F | Cracks, seepage and efflorescence observed in basement at upstream wall and left hand side wall and observed at ground floor upstream wall above deep well and extending downwards to basement.<br>To be monitored. |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | S | |
| Settlement- particularly fill adjacent to concrete structure | S | |
| Penstocks – corrosion; signs of distress/distortion | – | Not visible. |
| Drains – particularly collecting leakage from penstocks/intakes which may discharge through powerhouse | – | Not observed. |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| Item | Rating | Remarks |
|---|---|---|
| Tailrace / Draft Tube | – | Not visible |
| Superstructure steel frame | S | |
| Superstructure steel cladding at side walls and downstream wall | S | |
| Superstructure RC upstream wall | S | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Security | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Access Roads | S | Limited access due to remote site except during winter. Remote video monitoring recommended to monitor any public access. |
| Security Measures | F | Vehicle sensor near Snare Forks where winter road enters the area.<br>Doors and fences locked but additional surveillance is recommended to detect unauthorized visitors. |
| Any Security issues? | F | Live Internet cam and Video tape surveillance of powerhouse exteriors is recommended. Two way speakers for audio communication also suggested. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 1 | Date: | 13 July, 2006 |
| Feature: | Abutments | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | Massive rock abutments. |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | S | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 1 | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | |
| Erosion/ Rutting | S | |
| Camber | S | |
| Vegetation | S | |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | |

Notes: Crest lowered to act as a fuseplug spillway in the event of emergency.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 1 | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | |
| Vegetation | S | |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | N/A | |
| Other unusual conditions | – | |
| Notes: Dam lowered to act as emergency fuseplug spillway if required. | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

**Dam Safety Review - Inspection Checklist**

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 1 | Date: | 13-July ,2006 |
| Feature: | Upstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | F | On-going maintenance to remove vegetation. |
| Debris | S | |
| Other unusual conditions | – | |
| Notes: (1) Saddle dam lowered to act as emergency fuseplug spillway if required. | | |

Rating

S Satisfactory, will fulfil intended purpose

F Fair, will fulfil intended purpose, maintenance required

P Poor, may not fulfil intended purpose, maintenance/repair required

U Unsatisfactory, will not fulfil intended purpose, repair required

E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 2 | Date: | 13 July, 2006 |
| Feature: | Abutments | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | Right abutment is sound, massive rock. |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | N/A | |
| Vegetation | P | Left abutment requires clearing. Clearing along toe line required. |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 2 | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | Longitudinal “depressions” along upstream and downstream shoulders still evident. No change from previous inspection. |
| Settlement/depressions | S | Crest has signs of undulating profile. Re-evaluate following brushing. |
| Erosion/ Rutting | S | Re-evaluate following brushing. |
| Camber | S | As above. |
| Vegetation | P | Must be removed. Evaluation and assessment is difficult due to limited visibility. |
| Road surface and Access | P | Vegetation to be removed. |
| Barriers/no-post guardrail | N/A | |
| Burrows | N/A | |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 2 | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | Inspection limited due to vegetation. |
| Cracks (length + orientation) | S | Inspection limited due to vegetation. |
| Erosion/gulling | S | Inspection limited due to vegetation. |
| Slides or sloughing | S | Inspection limited due to vegetation. |
| Bulging/Distortion | S | Inspection limited due to vegetation. |
| Seepage/wet areas (indicate clarity of observed seepage | S | None observed. |
| Vegetation | P | Must be removed to permit inspection and evaluation. |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | N/A | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Saddle Dam 2 | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny & Warm |
| Detail: | | Reservoir Level: | 663.61 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | Vegetation may be masking deficiencies, but ample freeboard provided. |
| Erosion/beaching | S | Same as above. |
| Settlement/depressions | S | Same as above. |
| Slides or sloughing | S | Same as above. |
| Sink holes | S | Same as above. |
| Vegetation | P | Slope overgrown with bushes and saplings. Must be removed to allow proper inspection. |
| Debris | S | |
| Other unusual conditions | – | |
| Notes: (1) Dam to be inspected following thorough brushing. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 2006 |
| Feature: | Gate 1 | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | S | Heated gate; structure enclosed. |
| Wheels and bearings | S | Reported good |
| Roller paths | S | Reported good |
| Gate guides | S | Reported good |
| Gate / Guide Heating | S | 4 gain heaters |
| Lifting Lug | S | |
| Dogging device | S | n/a |
| Seals/leakage | S | Minor leakage along sides and sill. |
| Clearances | S | good |
| Actuator | S | see hoist reporting sheet |
| • Motors | | |
| • Gearboxes | | |
| • Manual operator | | |
| Actuator heating / weather protection | S | insulation poor but adequate for hoist operation |
| Other unusual conditions | S | |
| Notes: Gates were inspected in 2004. Internal heating elements repaired at that time. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 2006 |
| Feature: | Gate 2 | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | S | Gate not heated. Structure in good condition. Inspected in 2004. |
| Wheels and bearings | S | |
| Roller paths | S | No reported problems with gate or hoist. |
| Gate guides | S | |
| Lifting Lug | S | |
| Dogging device | S | |
| Seals/leakage | S | Very little leakage observed |
| Clearances | S | |
| Actuator | S | Screw stem hoist |
| • Motors | S | 600 vac from station service |
| • Gearboxes | S | |
| • Manual operator | S | socket connection for portable tool |
| Heating / weather protection | S | poor insulation but does not affect hoist operation |
| Other unusual conditions | | |

Notes: Gate has power supply for heaters. Heater elements to be installed in future. No gain heaters.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 2006 |
| Feature: | Hoists (2 screw stem) | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Hoist | | |
| • structure | S | Painted and in good condition |
| • motor | S | No problems reported with hoists |
| • gearbox | S | |
| Hoist weather protection | S | |
| Operation | S | |
| Indicators (mechanical) | S | Scale painted on structure |
| Position Transducers | S | Present but not connected |
| Limit Switches | S | High and low with motor interlocks |
| Controls | S | Local pushbutton panel at deck level |
| Operating Procedures | S | |
| Maintenance Records | S | |
| Test Records | S | |
| Other unusual conditions | S | |

Notes: Electric screw stem hoists with gas and manual backup.
Hoists have never been fully opened.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 2006 |
| Feature: | Standby Power | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | Manual clutch on hoist |
| Fuel Tank | S | Gas tanks on each hoist |
| Enclosure | | |
| • venting | S | |
| • exhaust | S | |
| • heating | S | |
| Battery Charging | S | |
| Operational Test | | |
| • persons to operate | S | |
| • ease of operation | S | |
| • raise gate | S | |
| • control system | S | |
| Emergency Communication System | S | Radio only |
| Operating Procedures | S | In control room |
| Maintenance / Test Records | S | In Yellowknife |
| Other unusual conditions | S | |

Notes: Both gates have auxiliary gas engines and a 1-1/2” socket connection to raise the gate manually with a portable air or electric tool.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 2006 |
| Feature: | Stoplogs | Weather: | Sunny |
| Detail: | | Reservoir Level: | 663.61 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| General Condition | S | Good |
| Stoplog Structure | S | |
| Stoplog Seals | S | Wood seals |
| Stoplog Slots / Guides | S | Good |
| Stoplog Follower | S | Good |
| • latching mechanism | S | |
| • roller guides | S | |
| Operating Procedures | S | Simple monorail hoist |
| Maintenance Records | S | In Yellowknife |
| Operating Records | S | Used to isolate spillway gate |
| Test Records | S | Not required for DSR |
| Other unusual conditions | S | No |

Notes: Stoplogs only used to isolate spillway gates for inspection and maintenance.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 06 |
| Feature: | Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 202.27 m (663.61') |
| Inspector: | D. Duivestein | | Both spillways open & discharging |

| Item | Rating | Remarks |
|---|---|---|
| General surface condition of RC | S | Concrete sound when impacted with a light chipping hammer. |
| Surface condition of spillway piers | F | Erosion below waterline, displaying a coarse aggregate type finish. To be monitored. |
| General condition of RC | S | |
| Cracks / Spalling at gate slots | F | Vertical cracks and potential major spalling adjacent to the left spillway heated gate embeds (gains). To be repaired. Similar to Spillway 5B but not as severe. |
| Cracks in sloping downstream walls of chute | F | Major transverse crack through each wall against rock (lhs wall of lhs chute, rhs wall of rhs chute). To be monitored. |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | S | |
| Settlement- particularly fill adjacent to concrete structure | S | |
| Steel superstructure for hoist | F | Requires painting. |
| Gate storage on Intake deck | P | Seismic restraints recommended. |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Falls Development**

| Item | Rating | Remarks |
|---|---|---|
| Overflow Weir | S | Observed from intake deck and bridge. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

**Dam Safety Review - Inspection Checklist**

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Approach Channel Dyke | Date: | 14 July 06 |
| Feature: | | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 183.56 m (602.23') |
| Inspector: | R. Douglas | | Spillway discharging |

| Item | Rating | Remarks |
|---|---|---|
| Visual condition | S | Crest survey recommended documenting the fill placement undertaken to cover the exposed concrete cut-off wall. |
| Slope protection | S | |
| Slides or sloughing | S | |
| Erosion | S | |
| Vegetation | F | Minor brushing to be undertaken as part of on-going maintenance. |
| Debris | F | Minor accumulations near the Intake to be removed during next brushing. |
| Settlement / depressions | S | New survey to document modified as built arrangement |
| Seepage/ wet areas | S | |
| Burrows | S | |
| Other unusual conditions | S | Slight narrowing of the crest in the vicinity of the new rockfill placement. New survey to document modified as built arrangement. |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

**Dam Safety Review - Inspection Checklist**

**Project: Snare Cascades Development**

| Item | Rating | Remarks |
| --- | --- | --- |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 2006 |
| Feature: | Communications | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.56 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Normal Facilities | | |
| • type | S | Phone and Radio |
| • adequacy | S | Good |
| Standby/Emergency Facilities | | |
| • type | S | Station batteries and station diesel |
| • adequacy | S | Good |
| Normal Power Supply | | |
| • type | S | Station service system |
| • reliability | S | Good |
| Auxiliary/Emergency Power | | |
| • type | S | Station service supply from Snare Falls |
| • tested | S | At annual maintenance outage |
| • maintenance | S | Adequate |
| • Tested during inspection? | S | No, but used regularly |
| Remote controls | S | From Yellowknife control centre |
| Annunciation/Indication | S | |
| Failure History | S | No significant problems noted |

Notes:

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

**Dam Safety Review - Inspection Checklist**

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Emergency Preparedness Plan | Reservoir Level: | 183.55 m |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | February 2006 |
| Date of Last Revision | S | |
| Current Copy at Dam? | F | Pdf copy available electronically |
| Adequacy of instructions? | F | |
| Are instructions understood? | F | Need record of Operators review of EPP |
| Inundation mapping included? | P | |
| Emergency contact list up to date? | S | |
| Primary/secondary access routes identified? | S | |
| Access during adverse weather | F | Access could be difficult during winter |
| Adequacy of notification charts | S | Up to date and posted |
| Flow chart of actions required in emergency | S | |
| Extent of distribution | U | EPP binder should be in control room |
| Types of tests | U | No tests of EPP system noted |
| Frequency of tests? | U | No tests of EPP system noted |
| Are tests recorded? | U | No |

Notes:

Actual implementation of notification procedure for dam breach occurred in June 2006 for saddle dam breach at Snare Forks plant. EPP notification procedures should be tested once a year to verify all contacts are up to date and the contacts know how to respond to notifications.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 14 July 2006 |
| Feature: | Gate | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | S | Installed October 1995 and remains in good |
| Wheels and bearings | S | condition. Guides, wheels and bearings not |
| Roller paths | S | observed as gate was under water |
| Gate guides | S | Reported in good condition |
| Gate / Guide Heating | S | Gate is inside powerhouse |
| Lifting Lug | S | Good |
| Dogging device | S | |
| Seals/leakage | S | Reported good |
| Clearances | S | Reported good |
| Actuator | S | Indoor wire rope hoist (see other sheet) |
| • Motors | S | |
| • Gearboxes | S | |
| • Manual operator | S | |
| Actuator heating / weather protection | S | Indoor |
| Other unusual conditions | S | No |

Notes: Gate fabricated by Allied Fabricators, Paris, ON.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 14 July 2006 |
| Feature: | Hoist | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Hoist | | |
| • structure | S | Electric wire rope hoist inside powerhouse |
| • motor | S | Good |
| • holding brake | S | Shoe type w/ solenoid and manual release |
| • gearbox | S | Planetary type: Good |
| • fan brake | S | Good; Louvers set for lowering speed |
| • wire rope | S | Good |
| Hoist weather protection | S | Good |
| Operation | S | Good |
| Indicators (mechanical) | S | On hoist |
| Position Transducers | S | Limit switches only |
| Limit Switches and Controls | S | Functional, local raise only |
| Operating Procedures | S | In Control room |
| Maintenance Records | S | In Yellowknife |
| Test Records | S | Commissioned 1996 and tested annually |
| Other unusual conditions | S | No |

Notes: Closing from full open to sill takes 5 minutes on fan. Power close takes 12 minutes. Full raise takes 13 minutes. Control limit switches at close, crack, open and maintenance. Gate tested once a year.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 14 July 2006 |
| Feature: | Standby Power | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | Supplied from powerhouse station service which has battery and diesel backup. |
| Fuel Tank | S | |
| Enclosure | | |
| • venting | S | Located within powerhouse |
| • exhaust | S | |
| • heating | S | |
| Battery Charging | S | |
| Operational Test | | Tested annually |
| • persons to operate | S | |
| • ease of operation | S | |
| • raise gate | S | |
| • control system | S | |
| Emergency Communication System | S | Phone at gate hoist and radio backup |
| Operating Procedures | S | In control room |
| Maintenance / Test Records | S | In Yellowknife |
| Other unusual conditions | S | |

Notes: Controls are DC to allow remote gate drop if necessary. Failure of DC system will drop headgate by releasing brake and allowing gate to go down by gravity with speed controlled by the fan.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 14 July 2006 |
| Feature: | Structure | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.56 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | Good |
| General condition | S | Good |
| Cracks / Spalling | S | None observed in intake area of powerhouse |
| Corrosion of steel reinforcement | S | None observed |
| Movement (offsets) | S | None observed |
| Joints | S | Good |
| Settlement- particularly fill adjacent to concrete structure | S | Some settlement of roadway |
| Other unusual conditions | S | |

Notes: Intake gate and hoist are inside the powerhouse and protected by insulated weatherproof cladding on a steel structure.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 14 July 06 |
| Feature: | Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 183.56 m (602.23') |
| Inspector: | D. Duivestein | | |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | |
| General condition | S | |
| Cracks / Spalling | S | |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | S | |
| Settlement- particularly fill adjacent to concrete structure | S | |
| Steel superstructure for hoist | S | |

Notes: The intake is within the powerhouse enclosure. Very limited substructure was visible.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Log | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Frequency of entry. | S | As required by events |
| Information recorded: | S | Mostly events and operating information |
| Are changes required? | S | No |
| Other observations | S | Log is kept in control room. |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Orders | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | U | No assembled binder of operating orders exists. Operating information is contained in separate O&M manuals and instructions posted near equipment. Operating restrictions noted in EPP but not available in powerhouse control room. |
| Date of Last Revision | U | |
| Current Copy at Dam? | U | |
| Adequacy of instructions? | U | |
| Are instructions understood? | F | |
| Reporting requirements? | S | Reporting noted in OMS manual |
| Any special instructions? | S | No |
| Is flood routing covered? | U | No |
| Is special surveillance covered? | U | No |
| Are changes required? | U | Yes |
| Other observations | | |

Notes: A binder of operating orders should be assembled and located in each powerhouse control room and operator's housing.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | OM&S Manual | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | December 2005 |
| Date of Last Revision | S | February 2006 |
| Current Copy at Dam? | F | Available electronically in pdf format |
| Adequacy of instructions? | S | OMS Manual is comprehensive |
| Are instructions understood? | S | All Operators should review manual |
| Is flood routing covered? | S | Yes |
| Any special instructions? | S | Site specific instructions included |
| Are inspections recorded? | S | Yes |
| Frequency of inspections? | S | Major done annually, regular done daily |
| Are checklists available? | S | Yes |
| Are changes required? | S | No |

Notes: Station commissioning manual and test results located in control room. Also located 1992 feasibility study and 1999 Dam Inspection Report for License N1L4-1624.

Up to date OMS manual was submitted in electronic pdf format but it is recommended that a paper copy be available in the control room.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Powerhouse | Date: | 14 July 06 |
| Feature: | Overall Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 183.56 m (602.23') |
| Inspector: | D. Duivestein | | P/H in operation |

| Item | Rating | Remarks |
|---|---|---|
| General condition | S | |
| Surface condition | F | See notes below. |
| Cracks / Spalling | F | See notes below. |
| Corrosion of steel reinforcement | S | Corrosion not visible but possibly occurring at the cracks. |
| Movement (offsets) | S | |
| Joints | F | Horizontal construction joint e.g. in the basement left side wall downstream end shows major efflorescence. |
| Settlement- particularly fill adjacent to concrete structure | S | |
| Penstocks – corrosion; signs of distress/distortion | S | Penstock only visible from inside turbine pit. |
| Drains – particularly collecting leakage from penstocks/intakes which may discharge through powerhouse | – | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| Item | Rating | Remarks |
|---|---|---|
| Tailrace / Draft Tube | S | Draft tube stoplog slot is within the powerhouse and the stoplog is handled by the house crane. Very limited substructure was visible. |
| Draft Tube Chamber | F | The upstream face of the upstream wall has vertical cracks and efflorescence when viewed from inside the powerhouse. |
| Turbine Pit | F | Major efflorescence deposits including at the interface of the penstock and the wall between the turbine pit and the basement. |
| RC Substructure floor and walls | P | Cracks and efflorescence observed. See Note 1. |
| Superstructure steel frame | S | |
| Superstructure steel sheet cladding | S | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

**Dam Safety Review - Inspection Checklist**

**Project: Snare Cascades Development**

| Item | Rating | Remarks |
|---|---|---|

Notes:

1. The interior face of the walls appear to have a poor quality, dark grey, plaster layer probably consisting of sand and cement. This layer may have been plastered on to hide previous deficiencies such as cracks. The plaster layer is softish and chips off easily possibly due to low cement content and high water cement ratio. This plaster layer is spalling in some places probably due to water leakage through the original substructure wall applying a pressure against it.
2. Floor paint is peeling off in places particularly at the downstream end of the basement floor adjacent to the upstream wall of the draft tube stoplog chamber. This might be caused by water accumulation from the leaks in the walls.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 14 July 2006 |
| Feature: | Security | Weather: | Sunny |
| Detail: | | Reservoir Level: | 183.55 m. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Access Roads | S | Site is remote with limited access except in winter. Local roads between the four stations are good. Some access security is in place. |
| Security Measures | F | Vehicle sensor near Snare Forks where winter road enters the area. Doors are generally locked and access to area is somewhat controlled. |
| Any Security issues? | F | More surveillance needed to detect fishermen or other unauthorized visitors around powerhouse, intake and spillway facilities. |

Notes:

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Cascades Development**

| | | | |
|---|---|---|---|
| Structure: | Labyrinth Spillway | Date: | 14 July 06 |
| Feature: | Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 183.56 m (602.23') |
| Inspector: | D. Duivestein | | Spillway discharging |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | |
| General condition | S | |
| Cracks/Joints | S | 2 minor vertical cracks in left side abutment upstream return wall. |
| Movement (offsets)- Check all joints for relative movement | S | |
| Settlement/depressions | S | |
| Erosion | S | Some coarse aggregate finish observed at top of labyrinth wall. |
| Debris | S | |
| Vegetation | S | |
| Other unusual conditions | | |

Notes:

1. Spillway was underwater. Reservoir level approx 0.6 m above spillway.
2. NWTPC reported a crack and leak in culvert type structure between the left side abutment wall and the first downstream V of the labyrinth wall.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Communications | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Normal Facilities | | |
| • type | S | Phone, radio |
| • adequacy | S | Good |
| Standby/Emergency Facilities | | |
| • type | S | Satellite phone |
| • adequacy | S | Good |
| Normal Power Supply | | |
| • type | S | AC Station service |
| • reliability | S | Good |
| Auxiliary/Emergency Power | | |
| • type | S | Diesel generator feeding station service |
| • tested | S | Every three months |
| • maintenance | S | Adequate |
| • tested during inspection? | S | No |
| Remote controls | S | Control from Yellowknife |
| Annunciation/Indication | S | |
| Failure History | S | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

**Dam Safety Review - Inspection Checklist**

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Emergency Preparedness Plan | Reservoir Level: | 571.97 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | February 2006 |
| Date of Last Revision | S | |
| Current Copy at Dam? | F | PDF copy available electronically. |
| Adequacy of instructions? | S | |
| Are instructions understood? | S | Need record of review by Operators |
| Inundation mapping included? | S | yes |
| Emergency contact list up to date? | S | June 2006 |
| Primary/secondary access routes identified? | S | |
| Access during adverse weather | F | Access could be difficult during winter |
| Adequacy of notification charts | S | Up to date and posted |
| Flow chart of actions required in emergency | S | |
| Extent of distribution | U | EPP binder should be in control room |
| Types of tests | U | No tests of EPP procedures noted |
| Frequency of tests? | U | No tests noted |
| Are tests recorded? | U | |

Notes: Actual implementation of notification procedure for dam breach occurred in June 2006 for saddle dam breach at Snare Forks plant. EPP notification procedures should be tested once a year to verify all contacts are up to date and the contacts know how to respond to notifications.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 1 | Date: | 13 July, 2006 |
| Feature: | All | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | - | |
| Cracks – longitudinal (length) | - | |
| Settlement/depressions | - | |
| Erosion/ Rutting | - | |
| Camber | - | See note (1) |
| Vegetation | - | |
| Road surface and Access | - | |
| Barriers/no-post guardrail | - | |
| Burrows | - | |
| Other unusual conditions | - | |
| Notes: (1) Dyke failed on 15 June 2006. Structure in process of being reconstructed at time of site visit. Not evaluated. Unsatisfactory in existing condition. | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 2 | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | Recently topped up. |
| Cracks – longitudinal (length) | S | Recently topped up. |
| Settlement/depressions | F | Survey to determine design level. Reinstatement over full dyke width required. |
| Erosion/ Rutting | S | |
| Camber | F | D/S shoulder appears lower than @ centreline. Crest survey to reinstate design level |
| Vegetation | S | Brushing required in future. |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | none |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 2 | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | F | Clear seepage (1-2L/S) from left abutment toe collects in ponded area at toe low print. 4 boils identified. See note (1). |
| Vegetation | S | |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | S | |
| Other unusual conditions | F | See note (1). |

Notes: (1) Within 30 m of right abutment 4 small buts observed discharging approximately 20 m from dyke toe. Discharges clear. Cover boils with reverse filters to prevent migration of foundation/embankment soils from them.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 2 | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | Clearing required in future. |
| Debris | S | Clearing required in future. |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 3 | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | Recently topped-up. |
| Cracks – longitudinal (length) | S | Recently topped-up. |
| Settlement/depressions | F | Area towards right abutment appears low. Survey required. |
| Erosion/ Rutting | S | |
| Camber | S | |
| Vegetation | S | |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 3 | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | |
| Vegetation | S | |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | S | |
| Other unusual conditions | - | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Freeboard Dyke 3 | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S/F | Some areas where finer riprap exists. Monitoring and replacement required prior to deterioration. |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | |
| Debris | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Gate | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Skinplate / Beams | S | Gate last inspected 2003. |
| Wheels and bearings | S | |
| Roller paths | S | Requires diver inspection |
| Gate guides | S | Requires diver inspection |
| Gate / Guide Heating | S | No problems reported |
| Lifting Lug | S | |
| Dogging device | S | Visible from deck; appears satisfactory. |
| Seals/leakage | S | No operating problems reported |
| Clearances | S | No operating problems reported |
| Heating / weather protection | S | |
| Other unusual conditions | S | Vent flaps satisfactory |

Notes: Gate can be brought up by the elevated hoist to maintenance position above the deck for inspection. Gate inspected every 5 years and was sandblasted and painted in approximately 1999.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Hoist | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Hoist | | |
| • structure | S | |
| • motor | S | 600 V from station service |
| • gearbox | S | Hansen; no problems reported |
| • fan brake | S | OK |
| • wire rope | P | ~9 yrs old; to be replaced in 2006 |
| Hoist weather protection | S | house with 2 space heaters |
| Operation | S | no problems reported |
| Indicators (mechanical) | S | limit switches only |
| Position Transducers | N/A | N/A |
| Limit Switches | S | Functional |
| Controls | S | Local raise & lower, remote lower only. |
| Operating Procedures | S | Posted on hoisthouse wall |
| Maintenance Records | S | In Yellowknife |
| Test Records | S | In Yellowknife |
| Other unusual conditions | S | no |

Notes: Closure test ~2 minutes (under power). Gate is tested once a year.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 2006 |
| Feature: | Standby Power | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Automatic/Manual Transfer Switch | S | Auto transfer to diesel backup system |
| Fuel Tank | S | |
| Enclosure | | |
| • venting | S | |
| • exhaust | S | Inside powerhouse. |
| • heating | S | |
| Battery Charging | S | |
| Operational Test | | |
| • persons to operate | S | Can be operated by one person |
| • ease of operation | S | No problems reported |
| • raise gate | S | Local control panel – raise & lower |
| • control system | S | Gate position on SCADA, remote drop only |
| Emergency Communication System | S | Phone and radio |
| Operating Procedures | S | Posted in gatehouse |
| Maintenance / Test Records | S | In Yellowknife |
| Other unusual conditions | S | No |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Intake | Date: | 13 July 06 |
| Feature: | Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 174.34 m (571.97') |
| Inspector: | D. Duivestein | | |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | S | |
| General condition | S | |
| Cracks / Spalling | S | |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | n/a | |
| Joints | S | |
| Settlement- particularly fill adjacent to concrete structure | n/a | |
| Steel superstructure for trashrack handling | F | Requires painting. |
| Steel cladding for hoist house walls and roof and gatehouse roof | F | Requires painting. |
| Other unusual conditions | S | Asbestos liner sheets inside elevated hoisthouse. |
| RC Superstructure columns, beam and floor slab for elevated hoist house. | S | |
| Concrete block gatehouse at deck level | S | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | North Dyke | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | F | Crest recently topped-up. Confirmatory survey to ensure design level achieved. |
| Erosion/ Rutting | S | |
| Camber | S | See above. |
| Vegetation | S | |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | North Dyke | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | D. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | F | Localized area of ponded water, no sign of flow or distinct seepage. On-going monitoring. |
| Vegetation | S | Brushing along toe line in future as part of on-going maintenance. |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| Item | Rating | Remarks |
|---|---|---|
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | North Dyke | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | Minor brush removal as part of on-going maintenance. |
| Debris | S | Minor accumulations removed as part of on-going maintenance. |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Log | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Frequency of entry. | S | As required by events |
| Information recorded: | S | Mostly events and operating information |
| Are changes required? | S | No |
| Other observations | | Log is kept in control room. |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | Operating Orders | Reservoir Level: | 571.97 ft |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | U | No binder of operating orders. Some posted operating information in plant and some information is in the EPP. |
| Date of Last Revision | U | |
| Current Copy at Dam? | U | No |
| Adequacy of instructions? | U | Generally adequate operating instructions exist, but are not assembled on one location |
| Are instructions understood? | U | |
| Reporting requirements? | S | Operating data reporting is adequate |
| Any special instructions? | S | No |
| Is flood routing covered? | U | In EPP |
| Is special surveillance covered? | S | No |
| Are changes required? | U | Yes |
| Other observations | | |

Notes: A binder of operating orders should be assembled and located in each powerhouse control room and operator's housing.

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Dam Safety Documentation | Weather: | Sunny |
| Detail: | OM&S Manual | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Issue Date | S | December 2005 |
| Date of Last Revision | S | February 2006 |
| Current Copy at Dam? | F | Available electronically in pdf format |
| Adequacy of instructions? | S | OMS Manual is comprehensive |
| Are instructions understood? | S | All Operators should review manual |
| Is flood routing covered? | S | Yes |
| Any special instructions? | S | Site specific instructions included |
| Are inspections recorded? | S | Yes |
| Frequency of inspections? | S | Major done annually, regular done daily |
| Are checklists available? | S | Yes |
| Are changes required? | S | No |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Powerhouse | Date: | 13 July 06 |
| Feature: | Overall Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 174.34 m (571.97') |
| Inspector: | D. Duivestein | | P/H in operation |

| Item | Rating | Remarks |
|---|---|---|
| General condition | S | |
| Surface condition | S | |
| Cracks / Spalling generally | S | |
| Cracks in Basement | F | Vertical cracks in downstream wall right hand side basement. |
| Corrosion of steel reinforcement | S | |
| Movement (offsets) | S | |
| Joints | S | |
| Settlement- particularly fill adjacent to concrete structure | F | Upstream side to be monitored. |
| Penstocks – corrosion; signs of distress/distortion | – | Not visible. |
| Drains – particularly collecting leakage from penstocks/intakes which may discharge through powerhouse | – | Not observed. |
| Tailrace / Draft Tube | S | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| Item | Rating | Remarks |
|---|---|---|
| RC Substructure extending to 3m above ground floor | S | |
| Superstructure steel framing | S | |
| Sheet steel cladding and roof | S | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

**Dam Safety Review - Inspection Checklist**

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | All | Date: | 13 July 2006 |
| Feature: | Security | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft. |
| Inspector: | G. Stranks | | |

| Item | Rating | Remarks |
|---|---|---|
| Access Roads | S | Site is remote with limited access except in winter. Local roads between the four stations are good. Some access security is in place. Remote video monitoring is recommended to monitor public access. |
| Security Measures | S | Vehicle sensor near Snare Forks where winter road enters the area. |
| Any Security issues? | F | Access control relies on personnel observing visitors. Live Internet cam and Video tape surveillance of powerhouse exteriors is recommended. Two way speakers for audio communication also suggested. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Snare Forks Dam | Date: | 13 July, 2006 |
| Feature: | Abutments | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | |
| Cracks/joints/bedding | S | |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Snare Forks Dam | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | |
| Erosion/ Rutting | S | |
| Camber | S | |
| Vegetation | S | Brushing along crest shoulders required in future. |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

## Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Snare Forks Dam | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | Large pond at toe appears unchanged. Seepage monitoring from culvert through cofferdam during lower spillway discharges to be undertaken. |
| Vegetation | S | |
| Visual condition of Instrumentation (if any) | N/A | |
| Burrows | N/A | |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Snare Forks Dam | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Erosion/beaching | S/F | Riprap in small localized area of right abutment is finer than elsewhere, monitoring for deterioration required. |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | |
| Debris | S | Removal required. |
| Other unusual conditions | – | |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Spillway | Date: | 13 July 06 |
| Feature: | Overall Structure | Weather: | sunny, warm |
| Detail: | | Reservoir Level: | 174.34 m (571.97') |
| Inspector: | D. Duivestein | | Spillway discharging |

| Item | Rating | Remarks |
|---|---|---|
| Surface condition | – | Flow appeared smooth, i.e. no visibly damaged areas. |
| General condition | – | |
| Cracks/Joints | – | |
| Movement (offsets)- Check all joints for relative movement | – | |
| Settlement/depressions | – | |
| Erosion | – | |
| Debris | S | None observed. |
| Vegetation | S | None observed. |
| Other unusual conditions | | |

Notes:

Spillway was underwater. Reservoir Level approx 0.6 m above spillway crest.

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Strutt Lake Dam | Date: | 13 July, 2006 |
| Feature: | Abutments | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Seepage/wet areas | S | Abutment seepage along SW of powerhouse collected in head traced PVC pipe. Discharge point inaccessible for flow measurement. Seepage along SE side of P/H and switchyard evident, i.e. French drain does not intercept all flows. On going monitoring required. |
| Cracks/joints/bedding | S | |
| Erosion/Gullying | S | |
| Slides or sloughing | S | |
| Signs of instability | S | |
| Settlement | S | |
| Slope protection | S | |
| Vegetation | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Strutt Lake Dam | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | Crest to be surveyed at same time as North Dyke and other Freeboard Dykes. |
| Erosion/ Rutting | S | |
| Camber | S | |
| Vegetation | S | |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Strutt Lake Dam | Date: | 13 July, 2006 |
| Feature: | Crest | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Cracks – transverse (length) | S | |
| Cracks – longitudinal (length) | S | |
| Settlement/depressions | S | Crest to be surveyed at same time as North Dyke and other Freeboard Dykes. |
| Erosion/ Rutting | S | |
| Camber | S | |
| Vegetation | S | |
| Road surface and Access | S | |
| Barriers/no-post guardrail | N/A | |
| Burrows | S | |
| Other unusual conditions | – | None |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Strutt Lake Dam | Date: | 13 July, 2006 |
| Feature: | Downstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | |
| Cracks (length + orientation) | S | |
| Erosion/gulling | S | |
| Slides or sloughing | S | |
| Bulging/Distortion | S | |
| Seepage/wet areas (indicate clarity of observed seepage | S | |
| Vegetation | S | |
| Visual condition of Instrumentation (if any) | P | Reinstate 3 standpipe piezos between toe and switchyard. |
| Burrows | S | |
| Other unusual conditions | – | |
| Notes: | | |

Rating
S Satisfactory, will fulfil intended purpose
F Fair, will fulfil intended purpose, maintenance required
P Poor, may not fulfil intended purpose, maintenance/repair required
U Unsatisfactory, will not fulfil intended purpose, repair required
E Emergency repair needed, give details

NORTHWEST TERRITORIES POWER CORPORATION

# Dam Safety Review - Inspection Checklist

**Project: Snare Forks Development**

| | | | |
|---|---|---|---|
| Structure: | Strutt Lake Dam | Date: | 13 July, 2006 |
| Feature: | Upstream Slope | Weather: | Sunny |
| Detail: | | Reservoir Level: | 571.97 ft |
| Inspector: | R. Douglas | | |

| Item | Rating | Remarks |
|---|---|---|
| Slope protection | S | Monitor area to left of Intake, riprap size looks smaller than elsewhere. |
| Erosion/beaching | S | |
| Settlement/depressions | S | |
| Slides or sloughing | S | |
| Sink holes | S | |
| Vegetation | S | |
| Debris | S | Minor accumulation removed as part of on-going maintenance. |
| Other unusual conditions | – | None. |
| Notes: | | |

Rating

| | |
|---|---|
| S | Satisfactory, will fulfil intended purpose |
| F | Fair, will fulfil intended purpose, maintenance required |
| P | Poor, may not fulfil intended purpose, maintenance/repair required |
| U | Unsatisfactory, will not fulfil intended purpose, repair required |
| E | Emergency repair needed, give details |

# APPENDIX II

## Photographs

**Photo 1** Snare Rapids Main Dam – typical crest condition.

**Photo 2** Snare Rapids Main Dam – vegetation along crest shoulder and upstream face to be removed

**Photo 3** Snare Rapids Main Dam – woody debris accumulated along upstream face to be removed as part of regular maintenance.

**Photo 4** Snare Rapids Main Dam – downstream face in good condition, brushing recommended as part of regular maintenance.

**Photo 5** Snare Rapids Main Dam – heated sump collecting seepage from downstream left abutment. No inflows at time of inspection.

**Photo 6** Snare Rapids Intake – general arrangement

**Photo 7** Snare Rapids Main Dam – seepage collection and measurement sump for seepage from the central portion of the dam.

**Photo 8** Snare Rapids Power Tunnel – seepage collection and measurement sump for seepage from the power tunnel.

**Photo 9** Spillway 5B – general view from downstream. Q = 142 $m^3/s$.

**Photo 10** Spillway 5B – retaining wall along upstream right abutment retains fills from Side Dam 5B.

**Photo 11** Spillway 5B - timber crib retaining wall at downstream right abutment retains Side Dam 5B fills.

**Photo 12** Side Dam 5B – undercutting of pier between spillway Bay 2 and 3

**Photo 13** Spillway 5B – pier undercutting observed at other pier locations.

**Photo 14** Spillway 5B - cracks in the second stage concrete around the heated gains in spillway Bay 3 and 4.

**Photo 15** Spillway 5B - 1 cm bulge and corresponding tear in the left side steel embed of spillway Bay 4, approximately 2 m below deck level.

**Photo 16** Side Dam 5B – general arrangement of measuring weir constructed in 1999 downstream of Side Dam 5B seepage area.

**Photo 17** Side Dam 5B – area along left side of measuring weir structure where flow by-pass is observed to occur. Lateral extension of the wall is recommended to contain all future seepage flows.

**Photo 18** Side Dam 5B – typical crest condition. Brushing of crest and slopes required to permit proper inspection in the future.

**Photo 19** Side Dam 5B – apparent low point on crest near the right abutment.

**Photo 20** Side Dam 5B – finer riprap identified in some locations.

**Photo 21** Side Dam 4 – typical crest condition. Some minor erosion and undulations in profile. Brushing of crest and slopes required to permit proper inspection in the future.

**Photo 22** Side Dam 4 – some gullying on downstream face evident due to surface runoff.

**Photo 23** Side Dam 4 – upstream face riprap showing signs of deterioration towards the left abutment.

**Photo 24** Side Dam 4 – accumulations of woody debris near left abutment.

**Photo 25** Side Dam 4 – rockfill toe berm shows no signs of cracking identified in earlier reports. Brushing of toe and slope required to permit proper inspection in the future.

**Photo 26** Side Dam 9B – general view from upstream

**Photo 27** Side dam 9B – crest profile shows possible signs of minor settlement near centre – survey recommended to determine if topping-up is required to reinstate the crest design level.

**Photo 28** Side Dam 9B - upstream slope of the dam shows some signs of minor rutting in areas due to surface run-off. 30 cm layer of fine rockfill or crushed gravel recommended. Brushing required as part of on-going maintenance.

**Photo 29** Side Dam 9B – woody debris mat accumulating near upstream face.

**Photo 30** Side Dam 9B - downstream slope is in a satisfactory condition

**Photo 31** Snare Falls Main Dam – crest condition satisfactory. Brushing recommended as part of on-going maintenance.

**Photo 32** Snare Falls Dam – upstream riprap satisfactory. Brushing recommended as part of on-going maintenance.

**Photo 33** Snare Falls Dam – typical downstream slope.

**Photo 34** Snare Falls Spillway – general arrangement.

**Photo 35** Snare Falls Spillway – side channel auxiliary spillway concrete control structure.

**Photo 36** Snare Falls Spillway - diagonal cracks on the downstream end of both abutment piers unchanged from previous inspections.

**Photo 37** Snare Falls Spillway - vertical cracks in concrete adjacent to left gate guide (heated).

**Photo 38** Snare Falls Spillway – stoplogs in satisfactory condition and in close proximity for quick installation.

**Photo 39** Snare Falls Spillway - gate operation is by manual pushbutton from the control panel at road level.

**Photo 40** Snare Falls Intake- general arrangement.

**Photo 41** Snare Falls Intake – elevated hoist house and support structure general arrangement.


**Photo 42** Snare Falls Powerhouse – general arrangement.

**Photo 43** Saddle Dam No. 1 – crest lowered by 2.7 m in 2003 as an emergency flood handling improvement.

**Photo 44** Saddle Dam No. 1 – upstream face satisfactory. Brushing required as part of on-going maintenance.

**Photo 45** Saddle Dam No. 2 – Crest and slopes overgrown with saplings and dense brush. Brushing required to permit proper inspection.

**Photo 46** Saddle Dam No. 2 - discontinuous longitudinal depressions occurring near the upstream and downstream sides of the crest show no change from previous reports.

**Photo 47** Snare Cascades Spillway – flow over the labyrinth spillway is smooth and uniform. Q = 126 $m^3/s$

**Photo 48** Snare Cascades Power Canal Dyke – crest typically planar with no obvious settled areas, erosion or abnormalities.

**Photo 49** Snare Cascades Power Canal Dyke – slight narrowing of the crest at about mid-dyke in an area where additional rockfill has been added to cover the previously observed exposures of concrete cut-off wall.

**Photo 50** Snare Cascades Power Canal Dyke - upstream slope is typically planar with a slight distortion in the slope of the fill in the area where the new rockfill was added. The rockfill is in good condition.

**Photo 51** Snare Cascades Power Canal Dyke - downstream slope is planar with no signs of erosion, instability or seepage.

**Photo 52** Snare Cascades Power Canal Dyke - crest of the lower bench is typically planar with no signs of instability or distress.

**Photo 53** Snare Cascades Power Canal Dyke - some localized depressions in the surface of the lower bench crest near the upstream end.

**Photo 54** Snare Cascades Power Canal Dyke - downstream slope of the lower bench is planar, with no signs of instability or other distress. The rockfill protection appears sound and in good condition.

**Photo 55** Snare Cascades Power Canal Dyke - localized area on the lower slope where the rockfill appears finer than the surrounding material, but there is currently no associated beaching or erosion. Brushing recommended..

**Photo 56** Snare Cascades Intake and Powerhouse – general arrangement.

**Photo 57** Snare Cascades Intake and Powerhouse - steel frame superstructure including the cladding appears in sound condition.

**Photo 58** Snare Cascades Intake and Powerhouse - multiple zones of cracks, seepage and efflorescence.

**Photo 59** Snare Forks Spillway - flow over the concrete spillway is smooth with no irregularity in the flow pattern, Q = 85 $m^3$/s.

**Photo 60** Snare Forks Spillway - excavated channel downstream of the spillway control structure is in good condition.

**Photo 61** Snare Forks Dam - culvert installed through the cofferdam. Invert slightly below pond level.

**Photo 62** Snare Forks Dam – the outlet of the culvert through the cofferdam is partly submerged during spillway operation precluding seepage measurement.

**Photo 63** Snare Forks Dam – crest planar with no signs of settlement, cracks or erosion.

**Photo 64** Snare Forks Dam - upstream slope typically shows no signs of settled areas or instability with no erosion or beaching of the riprap evident.

**Photo 65** Snare Forks Dam - downstream shell is planar with no settled areas or evidence of instability.

**Photo 66** Freeboard Dyke 1 – reconstruction in progress following breach in June 2006.

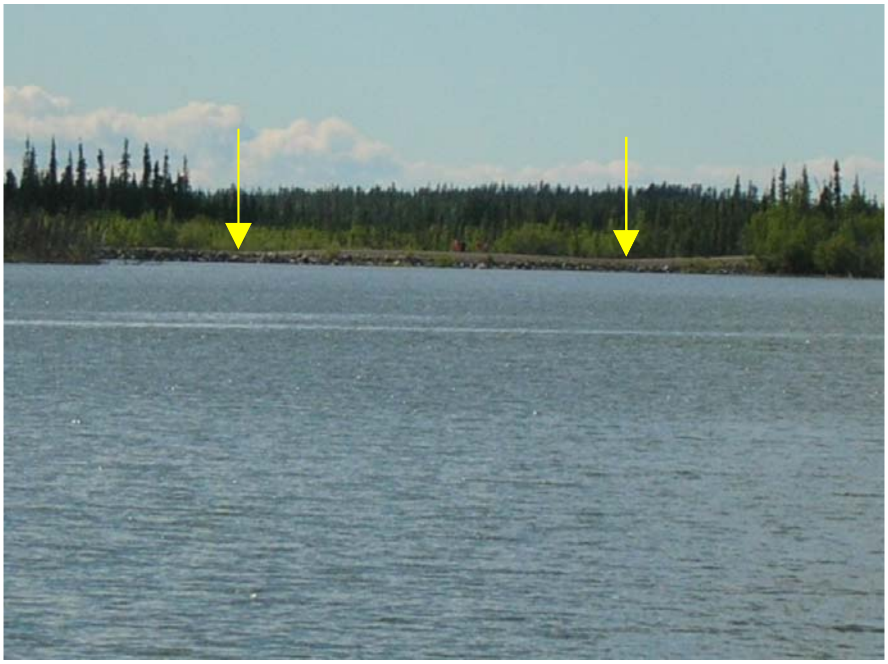


**Photo 67** Freeboard Dyke 2 - crest exhibits an undulating profile with two visible depressions in the crest – one at each abutment.

**Photo 68** Freeboard Dyke 2 – crest exhibits no longitudinal cracking but recently placed sand fill may mask actual condition.

**Photo 69** Freeboard Dyke 2 - downstream shoulder of the dyke cross section appears lower than at the centerline.

**Photo 70** Freeboard Dyke 2 – riprap on upstream face is in acceptable condition.

**Photo 71** Freeboard Dyke 2 - ponded water along the downstream toe originates from foundation seepage at the left abutment.

**Photo 72** Freeboard Dyke 2 –seepage from foundation flows down the toe of the downstream slope, collecting in the low point.

**Photo 73** Freeboard Dyke 2 – small boil (5 cm max) discharging clear water beneath the ponded water within approximately 2 m of the toe of the dyke. .

**Photo 74** Freeboard Dyke 2 - upstream riprap generally satisfactory.

**Photo 75** Strutt Lake Dam – toe of dam in vicinity where 3 standpipe piezometers were previously installed in March 2000.

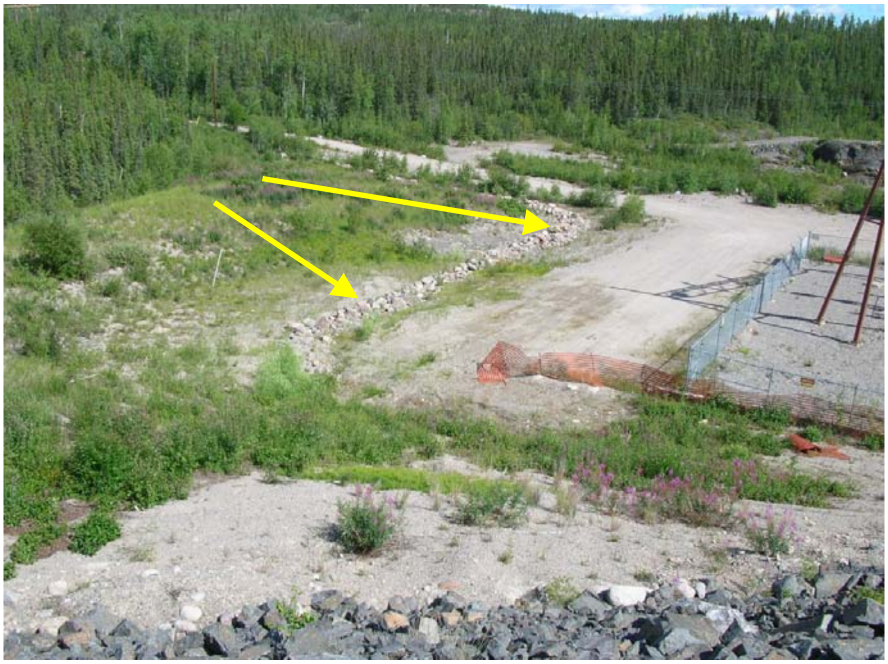


**Photo 76** Strutt Lake Dam - rock fill French drain between downstream toe and switchyard. Drain outflows not monitored. Dry at the time of inspection.

**Photo 77** Strutt Lake Dam - crest is planar, with no visible settlement, cracks or erosion.

**Photo 78** Strutt Lake Dam - downstream shell of the dam is planar with no settled areas, erosion gulleys or evidence of abutment seepage.

**Photo 79** Strutt Lake Dam - riprap on the upstream slope is generally satisfactory. Localized area immediately left of the intake lacks some larger size particles. Monitoring required.

**Photo 80** Snare Forks Powerhouse - heat traced perforated PVC pipe installed along the SW side of the powerhouse to address the minor seepage observed from the rockfill downstream.


**Photo 81** Snare Forks Powerhouse - some dampness along the SW side of the powerhouse evident, but there is no longer observable seepage.

**Photo 82** North Dyke – crest recently topped-up at the time of inspection and appeared to be in satisfactory condition. The crest is planar with no cracks, settled areas or erosion.

**Photo 83** North Dyke - riprap on the upstream face is satisfactory. .

**Photo 84** North Dyke - downstream shell is planar, with no erosion gulleys or evidence of seepage.

**Photo 85** Snare Forks Powerhouse - minor seepage through the bedrock near the SE corner of the powerhouse and switchyard as evident by the ponded water at the switchyard retaining wall.

**Photo 86** Snare Forks Intake – general arrangement.

**Photo 87** Snare Forks Powerhouse – general arrangement.

# APPENDIX III

## Seismic Hazard Analysis

# 2005 National Building Code Seismic Hazard Calculation

**INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
**Western Canada English (250) 363-6500 Facsimile (250) 363-6565**

Requested by: Winson Cheng, Klohn Crippen Berger Ltd. July 21, 2006

Site Coordinates: 63.4333 North 116.18 West

User File Reference: Snare Falls G.S.

**National Building Code ground motions:**
**2% probability of exceedance in 50 years (0.000404 per annum)**

| Sa(0.2) | Sa(0.5) | Sa(1.0) | Sa(2.0) | PGA (g) |
|---|---|---|---|---|
| **0.116** | **0.056** | **0.023** | **0.008** | **0.059** |

**Notes.** Spectral and peak hazard values are determined for firm ground (NBCC 2005 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

| | | | |
|---|---|---|---|
| Probability of exceedance per annum | 0.010 | 0.0021 | 0.001 |
| Probability of exceedance in 50 years | 40% | 10% | 5% |
| Sa(0.2) | 0.015 | 0.044 | 0.069 |
| Sa(0.5) | 0.008 | 0.024 | 0.036 |
| Sa(1.0) | 0.004 | 0.009 | 0.014 |
| Sa(2.0) | 0.003 | 0.005 | 0.007 |
| PGA | 0.007 | 0.021 | 0.035 |

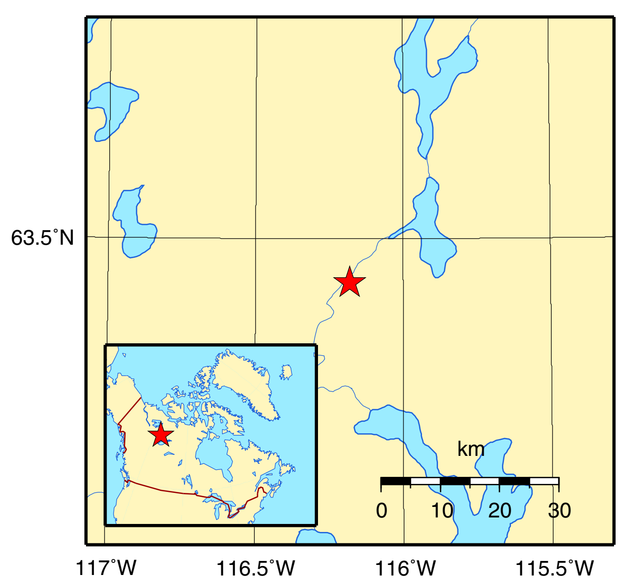
**References**

**National Building Code of Canada 2005 NRCC no. 47666;** sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
**Appendix C:** Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

**User's Guide - NBC 2005, Structural Commentaries NRCC no. xxxxx**
**Commentary J:** Design for Seismic Effects

**Geological Survey of Canada Open File xxxx**
Fourth generation seismic hazard maps of Canada: Grid values to be used with the 2005 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information




*Aussi disponible en français*

Natural Resources Canada

Ressources naturelles Canada

Canada

# APPENDIX IV

## Instrumentation Readings

# SPILLWAY 5B Leakage Weir Flow

1.33 ft = weir l    3.33x l x d^1.5

| Date | Forebay | depth (in) | depth (ft) | flow (cfs) | flow (l/min) | comments |
|---|---|---|---|---|---|---|
| 26-Sep-00 | 728.36 | 0.95 | 0.079 | 0.099 | 168 | some bypass |
| 04-Oct-00 | 728.34 | 1.00 | 0.083 | 0.107 | 181 | some bypass |
| 15-May-01 | 721.4 | 1.00 | 0.083 | 0.107 | 181 | |
| 15-Jul-01 | 727.34 | 1.10 | 0.092 | 0.123 | 209 | some bypass |
| 12-Sep-01 | 726.89 | 0.90 | 0.075 | 0.091 | 155 | |
| 10-Jun-02 | 718.18 | 0.75 | 0.063 | 0.069 | 118 | |
| 10-Aug-02 | 719.87 | 0.75 | 0.063 | 0.069 | 118 | |
| 03-Oct-02 | 724.68 | 0.95 | 0.079 | 0.099 | 168 | |
| 24-Mar-03 | 725.82 | 1.00 | 0.083 | 0.107 | 181 | |
| 04-May-03 | 723.92 | 1.00 | 0.083 | 0.107 | 181 | |
| 15-May-04 | 718.08 | 1.10 | 0.092 | 0.123 | 209 | |
| 16-Jul-04 | 718.22 | 0.95 | 0.079 | 0.099 | 168 | |
| 12-Sep-04 | 722.86 | 0.90 | 0.075 | 0.091 | 155 | |
| 17-Mar-05 | 722.26 | 0.85 | 0.071 | 0.084 | 142 | |
| 14-May-05 | 719.28 | 1.00 | 0.083 | 0.107 | 181 | |
| 17-Jul-05 | 725.54 | 1.00 | 0.083 | 0.107 | 181 | |
| 07-Sep-05 | 728.62 | 1.10 | 0.092 | 0.123 | 209 | some bypass |
| 26-May-06 | 728.62 | 0.95 | 0.079 | 0.099 | 168 | some bypass |
| 10-Jun-06 | 728.22 | 0.95 | 0.079 | 0.099 | 168 | some bypass |
| 22-Jun-06 | 729.26 | 1.00 | 0.083 | 0.107 | 181 | some bypass |
| 12-Jul-06 | 728.06 | 1.00 | 0.083 | 0.107 | 181 | some bypass |
| 21-Jul-06 | 728.54 | 1.00 | 0.083 | 0.107 | 181 | some bypass |

# Snare Rapids Dam
# Core Temps
## Raw data

| | depth ( m ) | (correction) DATE | 04-Mar-00 | 19-May-00 | 06-Jun-00 | 12-Jul-00 | 18-Aug-00 | 24-Sep-00 | 19-Oct-00 | 15-Nov-00 |
|---|---|---|---|---|---|---|---|---|---|---|
| ambient | | | -9.9 | -13.6 | 8.6 | 13.7 | 14.1 | 1.8 | -3 | -8 |
| | 0.5 | | | | | | | | | |
| 1 | 1.0 | -0.01 | 24.70 | 15.99 | 12.10 | 8.10 | 9.14 | 12.05 | 14.71 | 17.44 |
| | 1.5 | | | | | | | | | |
| 2 | 2.0 | -0.01 | 19.76 | 17.08 | 16.50 | 13.43 | 11.29 | 11.97 | 13.53 | 14.8 |
| 3 | 2.5 | 0.02 | 17.75 | 17.24 | 16.90 | 16.18 | 12.78 | 12.22 | 13.27 | 14.29 |
| 4 | 3.0 | 0.00 | 16.34 | 16.98 | 16.70 | 16.62 | 14.26 | 12.58 | 13.14 | 13.95 |
| 5 | 3.5 | 0.02 | 15.77 | 16.57 | 16.50 | 16.46 | 15.38 | 13.03 | 13.18 | 13.77 |
| 6 | 4.0 | -0.02 | 15.27 | 16.13 | 16.10 | 16.14 | 15.78 | 13.45 | 13.28 | 13.64 |
| 7 | 4.5 | 0.02 | 14.94 | 15.81 | 15.80 | 15.91 | 15.77 | 13.87 | 13.49 | 13.64 |
| 8 | 5.0 | -0.01 | 14.67 | 15.48 | 15.50 | 15.65 | 15.60 | 14.18 | 13.68 | 13.66 |
| 9 | 5.5 | 0.03 | 14.45 | 15.22 | 15.30 | 15.44 | 15.44 | 14.46 | 13.93 | 13.77 |
| 10 | 6.0 | 0.04 | 14.27 | 14.99 | 15.00 | 15.24 | 15.28 | 14.6 | 14.08 | 13.85 |

## Deg C

| | depth ( m ) | 04-Mar-00 | 19-May-00 | 06-Jun-00 | 12-Jul-00 | 18-Aug-00 | 24-Sep-00 | 19-Oct-00 | 15-Nov-00 | 15-Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|
| ambient | 0 | -9.9 | -13.6 | 8.6 | 13.7 | 14.1 | 1.8 | -3 | -8 | -40 |
| 1 | 1.0 | -7.9 | 0.4 | 6.0 | 14.3 | 11.7 | 6.0 | 2.0 | -1.3 | -12.7 |
| 2 | 2.0 | -3.7 | -0.9 | -0.2 | 3.9 | 7.4 | 6.2 | 3.7 | 1.9 | 0.3 |
| 3 | 2.5 | -1.6 | -1.0 | -0.7 | 0.2 | 4.9 | 5.8 | 4.1 | 2.6 | 1.2 |
| 4 | 3.0 | 0.0 | -0.8 | -0.4 | -0.4 | 2.7 | 5.2 | 4.3 | 3.1 | 1.8 |
| 5 | 3.5 | 0.7 | -0.3 | -0.2 | -0.1 | 1.2 | 4.5 | 4.3 | 3.4 | 2.4 |
| 6 | 4.0 | 1.3 | 0.2 | 0.2 | 0.2 | 0.6 | 3.8 | 4.1 | 3.5 | 2.7 |
| 7 | 4.5 | 1.8 | 0.6 | 0.7 | 0.5 | 0.7 | 3.2 | 3.8 | 3.6 | 3.1 |
| 8 | 5.0 | 2.1 | 1.0 | 1.0 | 0.8 | 0.9 | 2.8 | 3.5 | 3.5 | 3.2 |
| 9 | 5.5 | 2.4 | 1.4 | 1.3 | 1.1 | 1.1 | 2.4 | 3.2 | 3.4 | 3.2 |
| 10 | 6.0 | 2.7 | 1.7 | 1.7 | 1.4 | 1.3 | 2.2 | 3.0 | 3.3 | 3.2 |

# Snare Rapids Dam
# Core Temps
## Raw data

| | depth ( m ) | | 15-Dec-00 | 17-Jan-01 | 15-Mar-01 | 29-Mar-01 | 16-Apr-01 | 15-May-01 | 15-Jun-01 | 15-Jul-01 | 17-Oct-01 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ambient | | | -40 | -18 | -15 | -5.2 | 5 | 4.7 | 15 | 18.8 | -3.7 |
| | | 0.5 | | | | | | | | | |
| | 1 | 1.0 | 32.1 | 27.71 | 26.74 | 26.41 | 22.14 | 16.05 | 10.19 | 9.22 | 13.56 |
| | | 1.5 | | | | | | | | | |
| | 2 | 2.0 | 16.1 | 18.33 | 19.71 | 20.13 | 19.39 | 16.83 | 16.21 | 14.07 | 12.66 |
| | 3 | 2.5 | 15.4 | 16.36 | 17.91 | 18.2 | 18.19 | 16.87 | 16.33 | 16.43 | 12.52 |
| | 4 | 3.0 | 14.9 | 15.65 | 16.53 | 16.73 | 16.98 | 16.63 | 16.44 | 16.61 | 12.58 |
| | 5 | 3.5 | 14.5 | 15.16 | 15.95 | 16.24 | 16.23 | 16.18 | 16.14 | 16.41 | 12.2 |
| | 6 | 4.0 | 14.2 | 14.71 | 15.49 | 15.61 | 15.76 | 15.71 | 15.85 | 16.12 | 12.99 |
| | 7 | 4.5 | 14 | 14.43 | 15.15 | 15.29 | 15.44 | 15.48 | 15.5 | 15.89 | 13.29 |
| | 8 | 5.0 | 13.9 | 14.17 | 14.84 | 14.96 | 15.11 | 15.17 | 15.3 | 15.64 | 13.59 |
| | 9 | 5.5 | 13.9 | 14.03 | 14.61 | 14.73 | 14.87 | 14.85 | 15.09 | 15.44 | 13.8 |
| | 10 | 6.0 | 13.9 | 13.91 | 14.41 | 14.52 | 14.65 | 14.62 | 14.84 | 15.24 | 14.06 |

## Deg C

| | depth ( m ) | | 17-Jan-01 | 15-Mar-01 | 29-Mar-01 | 16-Apr-01 | 15-May-01 | 15-Jun-01 | 15-Jul-01 | 17-Oct-01 | 28-Feb-02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ambient | | 0 | -18 | -15 | -5.2 | 5 | 4.7 | 15 | 18.8 | -3.7 | -28 |
| | 1 | 1.0 | -10.0 | -9.4 | -9.2 | -5.9 | 0.3 | 9.5 | 11.6 | 3.7 | -13.0 |
| | 2 | 2.0 | -2.3 | -3.7 | -4.1 | -3.3 | -0.6 | 0.1 | 2.9 | 5.0 | -4.0 |
| | 3 | 2.5 | 0.0 | -1.8 | -2.1 | -2.1 | -0.6 | 0.0 | -0.1 | 5.3 | -1.9 |
| | 4 | 3.0 | 0.8 | -0.2 | -0.5 | -0.8 | -0.4 | -0.1 | -0.3 | 5.2 | -0.3 |
| | 5 | 3.5 | 1.5 | 0.5 | 0.1 | 0.1 | 0.2 | 0.2 | -0.1 | 5.8 | 0.6 |
| | 6 | 4.0 | 2.0 | 1.0 | 0.9 | 0.7 | 0.7 | 0.6 | 0.2 | 4.5 | 1.2 |
| | 7 | 4.5 | 2.4 | 1.5 | 1.3 | 1.1 | 1.1 | 1.0 | 0.5 | 4.1 | 1.7 |
| | 8 | 5.0 | 2.8 | 1.9 | 1.7 | 1.5 | 1.4 | 1.3 | 0.8 | 3.6 | 2.1 |
| | 9 | 5.5 | 3.0 | 2.2 | 2.1 | 1.9 | 1.9 | 1.6 | 1.1 | 3.3 | 2.4 |
| | 10 | 6.0 | 3.2 | 2.5 | 2.3 | 2.2 | 2.2 | 1.9 | 1.4 | 3.0 | 0.4 |

# Snare Rapids Dam
# Core Temps
## Raw data

| | depth ( m ) | | 28-Feb-02 | 15-Mar-02 | 15-Apr-02 | 24-Apr-02 | 18-May-02 | 24-May-02 | 14-Jun-02 | 06-Sep-03 | 15-Jul-06 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ambient | | | -28 | -29 | -10 | -8 | 14.1 | 0 | 20 | 18 | 18.8 |
| | | 0.5 | | | | | | | | | |
| | 1 | 1.0 | 32.64 | 36.79 | 28.35 | 24.33 | 17.14 | 15.78 | 9.96 | 8.9 | 8.89 |
| | | 1.5 | | | | | | | | | |
| | 2 | 2.0 | 20.09 | 20.82 | 20.96 | 20.26 | 17.86 | 17.36 | 16.21 | 11.4 | 14.67 |
| | 3 | 2.5 | 17.98 | 18.41 | 19.05 | 18.91 | 17.82 | 17.48 | 16.84 | 12.6 | 16.63 |
| | 4 | 3.0 | 16.61 | 16.63 | 17.35 | 17.47 | 17.22 | 17.13 | 16.8 | 13.9 | 35.51 ? |
| | 5 | 3.5 | 15.84 | 16.72 | 16.33 | 16.42 | 16.52 | 16.95 | 16.54 | 14.9 | 1.273 ? |
| | 6 | 4.0 | 15.37 | 15.53 | 15.82 | 15.89 | 16.06 | 16.1 | 16.12 | 15.4 | 16.07 |
| | 7 | 4.5 | 14.97 | 15.14 | 15.46 | 15.54 | 15.69 | 15.76 | 15.82 | 15.6 | 15.91 |
| | 8 | 5.0 | 14.66 | 17.52 | 15.12 | 15.2 | 15.36 | 15.41 | 15.53 | 1(open) | 16.1 |
| | 9 | 5.5 | 14.44 | 14.59 | 14.86 | 14.93 | 15.04 | 15.15 | 15.3 | 15.6 | 15.69 |
| | 10 | 6.0 | 16.06 | 14.6 | 14.64 | 14.71 | 14.88 | 14.9 | 15.08 | 15.2 | 15.33 |

## Deg C

| | depth ( m ) | | 15-Mar-02 | 15-Apr-02 | 24-Apr-02 | 18-May-02 | 24-May-02 | 14-Jun-02 | 06-Sep-03 | 15-Jul-06 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ambient | | 0 | -29 | -10 | -8 | 14.1 | 0 | 20 | 18 | 18.8 | 0 |
| | 1 | 1.0 | -15.1 | -10.5 | -7.6 | -1.0 | 0.7 | 9.9 | 12.3 | 12.3 | 0 |
| | 2 | 2.0 | -4.7 | -4.8 | -4.2 | -1.8 | -1.2 | 0.1 | 7.2 | 2.1 | 0 |
| | 3 | 2.5 | -2.3 | -3.0 | -2.8 | -1.7 | -1.3 | -0.6 | 5.2 | -0.3 | 0 |
| | 4 | 3.0 | -0.4 | -1.2 | -1.3 | -1.0 | -0.9 | -0.6 | 3.2 | | 0 |
| | 5 | 3.5 | -0.4 | 0.0 | -0.1 | -0.2 | -0.7 | -0.2 | 1.8 | | 0 |
| | 6 | 4.0 | 1.0 | 0.6 | 0.5 | 0.3 | 0.2 | 0.2 | 1.1 | 0.3 | 0 |
| | 7 | 4.5 | 1.5 | 1.1 | 1.0 | 0.8 | 0.7 | 0.6 | 0.9 | 0.5 | 0 |
| | 8 | 5.0 | -1.4 | 1.5 | 1.4 | 1.2 | 1.1 | 1.0 | | 0.3 | 0 |
| | 9 | 5.5 | 2.2 | 1.9 | 1.8 | 1.6 | 1.5 | 1.3 | 0.9 | 0.8 | 0 |
| | 10 | 6.0 | 2.2 | 2.2 | 2.1 | 1.9 | 1.8 | 1.6 | 1.4 | 1.3 | 0 |

## SNARE RAPIDS

0.50 ft = weir l    3.33x l x d^1.5

## Dam Leakage Weir Flow

| Date | Forebay | depth (in) | depth (ft) | flow (cfs) | flow (l/min) | comments |
|---|---|---|---|---|---|---|
| 09-Dec-98 | 728.55 | 1.00 | 0.083 | 0.040 | 68 | |
| 14-Dec-98 | 728.7 | 1.00 | 0.083 | 0.040 | 68 | |
| 21-Dec-98 | 728.8 | 1.00 | 0.083 | 0.040 | 68 | |
| 28-Dec-98 | 728.65 | 1.00 | 0.083 | 0.040 | 68 | |
| 07-Jan-99 | 728.42 | 1.50 | 0.125 | 0.074 | 125 | |
| 18-Jan-99 | 728.2 | 1.00 | 0.083 | 0.040 | 68 | |
| 24-Jan-99 | 728.13 | 0.75 | 0.063 | 0.026 | 44 | |
| 26-Jan-99 | 728.12 | 0.75 | 0.063 | 0.026 | 44 | |
| 14-Feb-99 | 727.7 | 0.75 | 0.063 | 0.026 | 44 | |
| 22-Feb-99 | 727.38 | 1.00 | 0.083 | 0.040 | 68 | |
| 10-Mar-99 | 726.88 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Mar-99 | 726.78 | 1.00 | 0.083 | 0.040 | 68 | |
| 24-Mar-99 | 726.52 | 1.75 | 0.146 | 0.093 | 158 | |
| 30-Mar-99 | 726.46 | 1.50 | 0.125 | 0.074 | 125 | |
| 06-Apr-99 | 726.22 | 1.50 | 0.125 | 0.074 | 125 | |
| 13-May-99 | 725.24 | 0.75 | 0.063 | 0.026 | 44 | |
| 25-May-99 | 725.14 | 1.00 | 0.083 | 0.040 | 68 | |
| 05-Jul-99 | 727.12 | 0.50 | 0.042 | 0.014 | 24 | |
| 29-Aug-99 | 727.46 | 2.50 | 0.208 | 0.158 | 269 | |
| 21-Oct-99 | 728.96 | 1.00 | 0.083 | 0.040 | 68 | |
| 23-Oct-99 | 728.94 | 1.00 | 0.083 | 0.040 | 68 | |
| 25-Oct-99 | 728.96 | 1.00 | 0.083 | 0.040 | 68 | |
| 29-Oct-99 | 728.98 | 1.00 | 0.083 | 0.040 | 68 | |
| 29-Nov-99 | 728.95 | 1.00 | 0.083 | 0.040 | 68 | |
| 01-Dec-99 | 729.02 | 1.00 | 0.083 | 0.040 | 68 | |
| 07-Dec-99 | 729.01 | 1.00 | 0.083 | 0.040 | 68 | |
| 01-Feb-00 | 727.8 | 1.50 | 0.125 | 0.074 | 125 | |
| 10-Feb-00 | 727.38 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Feb-00 | 727.24 | 1.00 | 0.083 | 0.040 | 68 | |
| 18-Feb-00 | 727.04 | 1.00 | 0.083 | 0.040 | 68 | |
| 04-Apr-00 | 724.74 | 1.50 | 0.125 | 0.074 | 125 | |
| 11-Apr-00 | 724.39 | 1.50 | 0.125 | 0.074 | 125 | |
| 17-Apr-00 | 724 | 1.00 | 0.083 | 0.040 | 68 | |
| 21-Apr-00 | 723.76 | 1.00 | 0.083 | 0.040 | 68 | |
| 01-May-00 | 723.08 | 1.00 | 0.083 | 0.040 | 68 | |
| 05-May-00 | 723.12 | 1.00 | 0.083 | 0.040 | 68 | |
| 08-Jun-00 | 721.04 | 1.00 | 0.083 | 0.040 | 68 | |
| 27-Jun-00 | 721.75 | 1.50 | 0.125 | 0.074 | 125 | |
| 04-Jul-00 | 722.6 | 1.50 | 0.125 | 0.074 | 125 | |
| 12-Jul-00 | 723.98 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Jul-00 | 724.08 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Jul-00 | 724.48 | 1.00 | 0.083 | 0.040 | 68 | |
| 16-Jul-00 | 724.54 | 1.00 | 0.083 | 0.040 | 68 | |
| 22-Jul-00 | 725.44 | 1.00 | 0.083 | 0.040 | 68 | |
| 05-Sep-00 | 728.5 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Sep-00 | 728.57 | 1.00 | 0.083 | 0.040 | 68 | |
| 22-Sep-00 | 728.36 | 1.00 | 0.083 | 0.040 | 68 | |
| 08-Oct-00 | 728.38 | 1.00 | 0.083 | 0.040 | 68 | |
| 7-Nov-00 | 728.35 | 1.00 | 0.083 | 0.040 | 68 | |

## SNARE RAPIDS

0.50 ft = weir l    3.33x l x d^1.5

## Dam Leakage Weir Flow

| Date | Forebay | depth (in) | depth (ft) | flow (cfs) | flow (l/min) | comments |
|---|---|---|---|---|---|---|
| 12-Dec-00 | 728.10 | 1.00 | 0.083 | 0.040 | 68 | |
| 23-Jan-01 | 727.04 | 1.25 | 0.104 | 0.056 | 95 | |
| 20-Feb-01 | 725.90 | 1.25 | 0.104 | 0.056 | 95 | |
| 20-Mar-01 | 724.34 | 1.00 | 0.083 | 0.040 | 68 | |
| 10-Apr-01 | 723.04 | 1.00 | 0.083 | 0.040 | 68 | |
| 9-May-01 | 721.08 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Jun-01 | 722.24 | 1.00 | 0.083 | 0.040 | 68 | |
| 11-Jul-01 | 727.39 | 1.25 | 0.104 | 0.056 | 95 | |
| 15-Aug-01 | 725.98 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Sep-01 | 726.89 | 1.00 | 0.083 | 0.040 | 68 | |
| 10-Oct-01 | 727.55 | 1.00 | 0.083 | 0.040 | 68 | |
| 21-Nov-01 | 727.34 | 0.75 | 0.063 | 0.026 | 44 | |
| 12-Dec-01 | 726.85 | 0.75 | 0.063 | 0.026 | 44 | |
| 16-Jan-02 | 725.48 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Feb-02 | 724.16 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Mar-02 | 722.59 | 1.00 | 0.083 | 0.040 | 68 | |
| 17-Apr-02 | 720.22 | 1.00 | 0.083 | 0.040 | 68 | |
| 16-May-02 | 718.58 | 1.00 | 0.083 | 0.040 | 68 | |
| 20-Jun-02 | 717.94 | 1.00 | 0.083 | 0.040 | 68 | |
| 20-Jul-02 | 717.92 | 1.25 | 0.104 | 0.056 | 95 | |
| 22-Aug-02 | 720.90 | 1.25 | 0.104 | 0.056 | 95 | |
| 5-Sep-02 | 723.04 | 1.00 | 0.083 | 0.040 | 68 | |
| 24-Oct-02 | 725.84 | 1.00 | 0.083 | 0.040 | 68 | |
| 28-Nov-02 | 727.64 | 1.50 | 0.125 | 0.074 | 125 | |
| 19-Dec-02 | 728.26 | 1.50 | 0.125 | 0.074 | 125 | |
| 9-Jan-03 | 728.10 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Feb-03 | 727.08 | 1.00 | 0.083 | 0.040 | 68 | |
| 20-Mar-03 | 725.82 | 1.00 | 0.083 | 0.040 | 68 | |
| 24-Apr-03 | 724.38 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-May-03 | 723.74 | 1.00 | 0.083 | 0.040 | 68 | |
| 13-Jun-03 | 723.24 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Jul-03 | 723.12 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Aug-03 | 723.88 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Sep-03 | 725.14 | 1.25 | 0.104 | 0.056 | 95 | |
| 10-Oct-03 | 725.76 | 1.25 | 0.104 | 0.056 | 95 | |
| 17-Nov-03 | 725.66 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Dec-03 | 725.16 | 1.00 | 0.083 | 0.040 | 68 | |
| 23-Jan-04 | 724.11 | 1.00 | 0.083 | 0.040 | 68 | |
| 23-Feb-04 | 722.84 | 1.00 | 0.083 | 0.040 | 68 | |
| 21-Mar-04 | 721.20 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Apr-04 | 719.74 | 1.00 | 0.083 | 0.040 | 68 | |
| 7-May-04 | 719.00 | 1.00 | 0.083 | 0.040 | 68 | |
| 17-Jun-04 | 717.84 | 1.00 | 0.083 | 0.040 | 68 | |
| 19-Jul-04 | 718.00 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Aug-04 | 720.72 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Sep-04 | 723.32 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Oct-04 | 724.44 | 1.25 | 0.104 | 0.056 | 95 | |
| 21-Nov-04 | 724.98 | 1.25 | 0.104 | 0.056 | 95 | |
| 17-Dec-04 | 724.64 | 1.50 | 0.125 | 0.074 | 125 | |

## SNARE RAPIDS

0.50 ft = weir l     3.33x l x d^1.5

## Dam Leakage Weir Flow

| Date | Forebay | depth (in) | depth (ft) | flow (cfs) | flow (l/min) | comments |
|---|---|---|---|---|---|---|
| 15-Jan-05 | 723.90 | 1.25 | 0.104 | 0.056 | 95 | |
| 15-Feb-05 | 723.20 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Mar-05 | 721.92 | 1.00 | 0.083 | 0.040 | 68 | |
| 10-Apr-05 | 720.50 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-May-05 | 719.28 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Jun-05 | 720.40 | 1.00 | 0.083 | 0.040 | 68 | |
| 11-Jul-05 | 725.54 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Aug-05 | 728.34 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Sep-05 | 729.26 | 1.00 | 0.083 | 0.040 | 68 | |
| 10-Oct-05 | 729.25 | 1.00 | 0.083 | 0.040 | 68 | |
| 17-Nov-05 | 728.80 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-Dec-05 | 729.32 | 1.00 | 0.083 | 0.040 | 68 | |
| 20-Jan-06 | 729.34 | 1.25 | 0.104 | 0.056 | 95 | |
| 20-Feb-06 | 729.08 | 1.00 | 0.083 | 0.040 | 68 | |
| 20-Mar-06 | 728.80 | 1.00 | 0.083 | 0.040 | 68 | |
| 15-Apr-06 | 728.20 | 1.00 | 0.083 | 0.040 | 68 | |
| 12-May-06 | 728.40 | 1.25 | 0.104 | 0.056 | 95 | |
| 13-Jun-06 | 729.26 | 1.25 | 0.104 | 0.056 | 95 | |
| 11-Jul-06 | 728.06 | 1.00 | 0.083 | 0.040 | 68 | |

# APPENDIX V

## Conformance of Snare Hydro to CDA Dam Safety Guidelines

# Table 14-2: 2006 Dam Safety Review
# Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | . | | | | | | | | | | |
| **1.0** | **SCOPE, DEFINITIONS AND GENERAL REQUIREMENTS** | | | | | | | | | | |
| **1.1** | **SCOPE AND APPLICABILITY OF THE GUIDELINES** | | | | | | | | | | |
| **1.2** | **DEFINITIONS** | | | | | | | | | | |
| **1.3** | **RESPONSIBILITY FOR DAM SAFETY** | | | | | | | | | | |
| **1.3.1** | **General** | | | | | | | | | | |
| | **1.3.1a** | **The responsibility for all aspects of the safety of a dam shall be clearly defined and delegation of responsibility and authority shall be documented.** | | | **X** | | | Snare OMS and EPP manuals | Updating and reorganization of the manuals is required. | | |
| **1.4** | **CLASSIFICATION OF DAMS** | | | | | | | | | | |
| | **1.4a** | **Each dam, water control structure or water passage, shall be classified in terms of the reasonably foreseeable incremental consequences of failure.** | **X** | | | | | | | | |
| | **1.4b** | **The loss of life consequences shall be evaluated separately from the socioeconomic, financial and environmental consequences and the higher of the two classifications shall be used.** | **X** | | | | | | | | |
| | **1.4c** | **For new dams, the consequences category shall be established during feasibility studies used for design, and confirmed prior to first reservoir filling.** | **N/A** | | | | | | Not a new dam | | |
| **1.5** | **SELECTION OF SAFETY CRITERIA** | | | | | | | | | | |
| | **1.5a** | **The dam, along with its foundation and abutments, shall be designed to have adequate stability to safely withstand extreme loads as well as the normal design loads.** | **X** | | | | | | | | |
| | **1.5b** | **The selection of loading criteria for extreme loads shall be based on the consequences of failure of the dam** | **X** | | | | | | | | |
| | **1.5c** | **For tailings dams, the loading criteria or level of safety at any stage of construction shall be commensurate with the consequences of failure at that stage , with due consideration of the consequences at future stages.** | **N/A** | | | | | | Not a tailings dam | | |
| **1.6** | **DECOMMISSIONING AND CLOSURE** | | | | | | | | | | |
| | **1.6a** | **A dam shall be decommissioned and considered closed only when all the requirements of a decommissioning plan hav been complied with.** | **N/A** | | | | | | Not applicable (dam is still in full operation). | | |
| | **1.6b** | **Demolition of a dam or removal of any of its appurtenances shall be based on sound practice and carried out without increasing the risk of failure of remaining structures and appurtenances or causing adverse impacts downstream of the dam.** | **N/A** | | | | | | Ditto | | |
| | **1.6c** | **Demolition operations shall not result in blockage or reduction of the safe discharge of natural floods. That part of the dam and its appurtenant structures which may obstruct the discharge of the water course or drainage course such that it causes upstream flooding beyond that of the existing dam and appurtenent structures or leads to a sudden release of water, must be completely removed.** | **N/A** | | | | | | Ditto | | |
| | **1.6d** | **Structures that remain after decommissioning shall be physically and chemically stable, and shall not impose an unacceptable risk to public health and safety, or the environment** | **N/A** | | | | | | Ditto | | |
| | **1.6e** | **Closure requirements for tailings dams must be considered and incorporated into the initial design stage and at all subsequent design and construction phases** | **N/A** | | | | | | Ditto | | |
| | **1.6f** | **Any tailings dam that retains contaminated or acid generating materials shall be monitored and maintained, to a level commensurate with the consequences of failure, after infilling is completed or mining operations are terminated.** | **N/A** | | | | | | Ditto | | |
| | . | | | | | | | | | | |
| **2** | **DAM SAFETY REVIEW** | | | | | | | | | | |
| **2.1** | **GENERAL** | | | | | | | | | | |
| | **2.1a** | **A Dam Safety Review (the "Review") shall be carried out by a qualified engineer (the "Engineer") at regular time intervals for dams and associated facilities. The review shall include the design, operation, maintenance, surveillance and emergency plans, to determine if they are safe in all respects and, if they are not, to determine required safety improvements.** | **X** | | | | | | | | |
| | **2.1b** | **The first Dam Safety Review for a new dam shall be completed within three years of initial filling** | **N/A** | | | | | | Not the first DSR | | |
| | **2.1c** | **A Dam Safety Review shall be carried out when there are significant changes in the stage of construction of a tailings dam, or the condition of any dam, including:** | **N/A** | | | | | | See individual comments below | | |
| | **2.1c.1** | **- Major modification to the original design or design criteria** | **N/A** | | | | | | | | |
| | **2.1c.2** | **- Discovery of an unusual condition;** | **N/A** | | | | | | Not applicable (no unusual condition prior to DSR) | | |
| | **2.1c.3** | **- Decommissioning;** | **N/A** | | | | | | Not applicable (facility still in full operation). | | |
| | **2.1c.4** | **- After an extreme hydrological or seismic event.** | **N/A** | | | | | | Not applicable (no extreme hydrological or seismic events). | | |
| **2.2** | **DETAILS OF REVIEW** | | | | | | | | | | |
| **2.2.1** | **Dam Classification** | | | | | | | | | | |
| | **2.2.1a** | **The Review shall include the classification of the dam, as outlined in Section 1.** | **X** | | | | | | | | |
| **2.2.2** | **Site Inspection** | | | | | | | | | | |

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.2.2a | **The Review shall include an appropriately comprehensive field inspection of the dam and appurtenant structures, and documentation thereof.** | | X | | | | | Power tunnel inspected by others in 2005 | | Inspect and document condition of Spillway 5B, bay 3 when conditions permit |
| **2.2.3** | **Design and Construction** | | | | | | | | | | |
| | 2.2.3a | **The Review of design and construction shall be sufficiently comprehensive to demonstrate whether the dam, discharge facilities and reservoir slopes meet all currently applicable safety requirements.** | | | | X | | | Intake stability not reviewed, inadequate drawings available. | | |
| **2.2.4** | **Operation and Testing** | | | | | | | | | | |
| | 2.2.4a | **The Review shall determine if safe operating procedures have been developed, documented and followed in all respects. The adequacy of the documentation shall be reviewed.** | X | | | | | Snare Hydro OMS manual | | | |
| | 2.2.4b | **The Review shall include the testing of equipment required to operate discharge facilities (including backup equipment and emergency power supply) that are required for the safe passage of the inflow design flood, and any other flood that could endanger the dam, and adequacy of ice and debris control facilities and procedures to verify that they will function as and when required.** | | | | X | | | Passage of IDF is via spillway 5B. Spillway operating equipment is tested annually, but no records of testing were provided | | |
| **2.2.5** | **Maintenance** | | | | | | | | | | |
| | 2.2.5a | **The Review shall ascertain if all facilities required for safety of the dam, including dam monitoring instrumentation, are maintained in satisfactory condition in accordance with a manual defining the maintenance requirements for dam safety.** | | | | X | | | No inspection or maintenance records were provided | | |
| **2.2.6** | **Surveillance and Monitoring of Dam Performance** | | | | | | | | | | |
| | 2.2.6a | **The Review shall determine if the surveillance and monitoring methods and frequency are adequate to detect any unsafe condition in a timely manner.** | X | | | | | | | | |
| | 2.2.6b | **The Review shall determine if monitoring data have been regularly analysed and used to ensure prompt detection of any potentially unsafe conditions in the dam, associated water containment and reservoir slopes.** | | | | X | | | No documentation available showing analysis of dam safety monitoring measurements or test results of operating equipment | | |
| **2.2.7** | **Emergency Preparedness** | | | | | | | | | | |
| | 2.2.7a | **The Review shall determine if the appropriate level of emergency preparedness exists and is adequately documented. The adequacy of warning systems, training and emergency response plans shall be reviewed, as well as testing and updating of plans.** | | | X | | | Snare Hydro EPP manual | Updating required. See report for specifics. | | |
| **2.2.8** | **Compliance with Previous Reviews** | | | | | | | | | | |
| | 2.2.8a | **Previous Dam Safety Reports shall be reviewed to determine compliance with their recommendations** | X | | | | | | | | |
| **2.3** | **DAM SAFETY REPORT** | | | | | | | | | | |
| | 2.3a | **A Dam Safety Report ("the Report"), covering all aspects of the dam's safety, shall be prepared, documenting the Dam Safety Review.** | X | | | | | | | | |
| | 2.3b | **The Report shall identify any additional steps required for the safe operation, maintenance and adequate surveillance of the dam.** | X | | | | | | | | |
| **2.4** | **FAILURE TO MEET REQUIREMENTS** | | | | | | | | | | |
| | 2.4a | **If the dam and/or appurtenant structures fails to meet the safety requirements, safety improvements shall be carried out as appropriate, including:** | | | | | | | | | |
| | 2.4a.1 | **- Safety improvements of the physical facilities;** | | | X | | | | See Table 14.1 for summary of deficiencies | | |
| | 2.4a.2 | **- Nonstructural improvements;** | | | X | | | | See Table 14.1 for summary of deficiencies | | |
| | 2.4a.3 | **- Overcoming any deficiencies in operation, surveillance, inspection or maintenance of the dam, or emergency preparedness.** | | | X | | | | See Table 14.1 for summary of deficiencies | | |
| **3.0** | **OPERATION, MAINTENANCE AND SURVEILLANCE** | | | | | | | | | | |
| **3.1** | **GENERAL** | | | | | | | | | | |
| | 3.1a | **Dam operation, maintenance and surveillance shall be provided so that an acceptable level of dam safety is ensured.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.1b | **A manual (the "OMS Manual") shall be prepared, documenting operation, maintenance and surveillance for each applicable dam. The OMS manual shall be implemented, followed, and updated at appropriate intervals. The manual shall contain suitable and sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition, and monitor its performance well enough to provide early signs of any distress.** | | | X | | | | Updating required. Refer to report for specifics. | | |
| | 3.1c | **For tailings dams a separate OMS Manual shall be prepared for the closure stage or included in the decommissioning plan.** | N/A | | | | | | Not Applicable (not a tailings dam) | | |
| | 3.1d | **Qualified personnel shall be used for the operation, maintenance and surveillance of a dam.** | | X | | | | | No documentation defining training and qualifications for operators relating to dam safety. | | |

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.1e | **Adequate records shall be maintained.** | | | | X | | | Station log documents operations and events, but not dam safety issues other than inspections. Test records of operating equipment were not available on site and were not located from maintenance files. | | |
| 3.2 | **OPERATION** | | | | | | | | | | |
| 3.2.1 | **Design Information** | | | | | | | | | | |
| | 3.2.1a | **The operation of the dam shall not violate any important design assumptions that could impair the safety of the dam.** | | | | | | | | | |
| 3.2.2 | **Flood Operating Procedures** | | | | | | | | | | |
| | 3.2.2a | **During the flood season, a sufficient number or capacity of gates and facilities necessary for discharging flows up to the Inflow Design Flood (IDF) shall be maintained in operable condition** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.2.2b | **Procedures for safe operation and any restrictions for gate operation shall be documented. The procedures shall list all operating restrictions, including drawdown so that any flows up to and including the IDF can be routed in a safe and consistent manner.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.2.2c | **The reservoir shall be operated in accordance with the documented procedures** | X | | | | | Snare Hydro OMS manual | | | |
| 3.2.3 | **Emergency Operating Procedures** | | | | | | | | | | |
| | 3.2.3a | **Procedures for reservoir control and discharge in the case of a developing breach or potential breach, and for any emergency drawdown of the reservoir shall be established** | X | | | | | Snare Hydro EPP manual | | Emergency drawdown is by fully opening spillway 5b and breaching dyke 9B. | |
| 3.2.4 | **Ice and Debris Handling** | | | | | | | | | | |
| | 3.2.4a | **Where reservoirs can contain significant quantities of ice or debris, procedures shall be established for safely handling ice and/or debris.** | | | X | | | | No procedure in evidence | | |
| 3.2.5 | **Flood Forecasting** | | | | | | | | | | |
| | 3.2.5a | **The source of any flood forecasting information shall be identified.** | X | | | | | | | | |
| 3.2.6 | **Water Balance for Tailings Basins** | | | | | | | | | | |
| | 3.2.6a | **For tailings basins, the water balance shall be reviewed on a periodic basis, at least annually, to ensure safe operation during flood or drought conditions** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| 3.3 | **MAINTENANCE** | | | | | | | | | | |
| | 3.3a | **Maintenance policies, procedures, records and responsibilities shall be developed and implemented to ensure that the dam, together with applicable structures and equipment required for flood discharge, is maintained in a safe and fully operable condition.** | | | X | | | Snare Hydro OMS manual | Responsibility for dam safety currently not defined | | |
| | 3.3b | **All Equipment related to dam safety shall be inspected and tested at regular intervals to ensure safe and reliable operation.** | | X | | | | Snare Hydro OMS manual | All gates and flow control equipment is tested and used annually. | Test documentation from previous years was not available. | |
| 3.4 | **SURVEILLANCE** | | | | | | | | | | |
| 3.4.1 | **Standards** | | | | | | | | | | |
| | 3.4.1a | **Standards shall be established for each dam to cover inspections, monitoring of fluid-retaining structures, and testing of discharge facilities.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.4.1b | **The level of surveillance shall be based on the Consequence classification of the dam** | X | | | | | | | | |
| 3.4.2 | **Regular Inspections** | | | | | | | | | | |
| | 3.4.2a | **In order to obtain baseline data, an initial inspection shall be performed on a new dam prior to the commencement of initial filling** | N/A | | | | | | Not a new dam | | |
| | 3.4.2b | **Periodic inspections shall be performed to determine the condition of integral portions of the fluid-retaining structure.** | | | | X | | | OMS manual specifies frequent inspections but inspection records were not available for review. | | |
| | 3.4.2c | **Appropriate investigations, as outlined in Section 2, shall be undertaken of all potential deficiencies disclosed by the regular inspections.** | X | | | | | | | | |
| | 3.4.2d | **Annual inspections shall be made of all operating tailings dams** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| 3.4.3 | **Special Inspections** | | | | | | | | | | |
| | 3.4.3a | **Special inspections shall be performed following potentially damaging events.** | N/A | | | | | | No known potentially damaging events have occurred | | |
| 3.4.4 | **Instrumentation** | | | | | | | | | | |
| | 3.4.4a | **Initial readings of all instruments shall be made and formalized as baseline data** | X | | | | | | Thermistor readings taken | | |
| | 3.4.4b | **Instrumentation shall be monitored, evaluated and maintained, and the data shall be compared with the previous readings and expected design values** | | X | | | | | Thermistor readings to be maintained seasonally. Seepage flows monitored. | | |
| 3.4.5 | **Tests** | | | | | | | | | | |
| | 3.4.5a | **All operating equipment and facilities necessary to pass the IDF shall be inspected and tested annually to ensure that they will function as required.** | X | | | | | Snare Hydro OMS manual | Spillway 5B log lifter is used frequently and maintained twice a year and additionally as required for operations. | | |
| 4.0 | EMERGENCY PREPAREDNESS | | | | | | | | | | |
| 4.1 | **GENERAL** | | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.1a | **Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken.** | X | | | | | Snare Hydro EPP manual | | | |
| | 4.1b | **An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage.** | X | | | | | Snare Hydro EPP manual | | | |
| | 4.1c | **A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.** | X | | | | | Snare Hydro EPP manual | The notification process received an operational test in 2006 when Freeboard Dyke 1 at Snare Forks failed due to overtopping. | | |
| | 4.1d | **Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.** | | | | X | | Snare Hydro EPP manual | | | |
| **4.2** | **EMERGENCY PREPAREDNESS PLAN** | | | | | | | | | | |
| **4.2.1** | **Development of an EPP** | | | | | | | | | | |
| | 4.2.1a | **An EPP shall describe the actions to be taken by the dam owner and operator in an emergency. The EPP shall assign responsibility for each action to an individual (identified by organizational position) and/or backup.** | | | | X | | | The notification process received an opertional test in 2006 when a saddle dyke failed due to overtopping near Snare Forks. The process did not work in time to prevent the breach. | | |
| | 4.2.1b | **Input from, and interfaces with, other agencies and affected parties shall be included in the EPP, as appropriate.** | | | | X | | | Affected parties and positions not adequately presented in EPP. | | |
| | 4.2.1c | **Copies of the EPP, or summaries of relevant information shall be provided to those who have responsibilities under the plan.** | | | | X | | | Distribution of the EPP is not controlled. | | |
| **4.2.2** | **Contents of an EPP** | | | | | | | | | | |
| | 4.2.2a | **The EPP shall include the following procedures and information** | | | | | | | | | |
| | 4.2.2a.1 | **- Emergency notification and evaluation;** | | | | X | | | Needs updating and better organization | | |
| | 4.2.2a.2 | **- Preventative actions (where available);** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.3 | **- Notification procedure;** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.4 | **- Notification flowchart;** | X | | | | | | Needs updating and better organization | | |
| | 4.2.2a.5 | **- Communication systems;** | X | | | | | | | | |
| | 4.2.2a.6 | **- Access to site;** | X | | | | | | | | |
| | 4.2.2a.7 | **- Response during periods of darkness** | X | | | | | | | | |
| | 4.2.2a.8 | **- Response during periods of adverse weather;** | X | | | | | | | | |
| | 4.2.2a.9 | **- Sources of equipment;** | | X | | | | | | | |
| | 4.2.2a.10 | **- Stockpiling supplies and materials** | | X | | | | | | | |
| | 4.2.2a.11 | **- Emergency power sources, if required;** | | X | | | | | | | |
| | 4.2.2a.12 | **- Inundation maps;** | | | | X | | | Add inundation maps | | |
| | 4.2.2a.13 | **- Warning systems (if used).** | | X | | | | | | | |
| **4.2.3** | **Maintenance and Testing of the EPP** | | | | | | | | | | |
| | 4.2.3a | **The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated** | | | X | | | | Distribution appears to be unregulated | | |
| | 4.2.3b | **The EPP shall be tested.** | | | X | | | | No documentation of annual testing but the EPP received the equivalent of a test during the 2006 dyke breach at Snare Forks. | | |
| | 4.2.3c | **For dams under construction, the EPP shall be reviewed annually and updated as appropriate** | N/A | | | | | | Not applicable (dam already built) | | |
| **4.2.4** | **Training** | | | | | | | | | | |
| | 4.2.4a | **Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties** | | | | X | | | No documentation of Operator training | | |
| **4.3** | **INUNDATION STUDIES** | | | | | | | | | | |
| | 4.3a | **A dam breach inundation study shall be carried out for all dams that clearly require EPPs (see Section 4.1) and for dams where it is not obvious whether or not an EPP is needed** | X | | | | | 2000 DSR | | | |
| | 4.3b | **The inundation study shall be based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions** | X | | | | | 2000 DSR | | | |
| **5.0** | **EARTHQUAKES** | | | | | | | | | | |
| | 5.0a | **Dams shall be designed and evaluated to withstand ground motions associated with a Maximum Design Earthquake (MDE), without release of the reservoir.** | X | | | | | This report | MDE based on 1000 year earthquake | | |
| | 5.0b | **Selection of the MDE for a dam shall be based on the consequences of dam failure** | X | | | | | This report | | | |
| **6.0** | **FLOODS** | | | | | | | | | | |
| **6.1** | **GENERAL** | | | | | | | | | | |
| | 6.1a | **Dams shall be designed and evaluated to safely pass an Inflow Design Flood (IDF). Selection of the IDF for a dam shall be based on the consequences of failure.** | X | | | | | 2000 DSR (re-confirmed this report) | | | |
| | 6.1b | **For new dams with very high or high consequences of failure, the maximum design floods at the dam site shall be evaluated by both statistical analysis and deterministic methods** | N/A | | | | | | Not applicable (not a new dam) | | |
| **6.2** | **STATISTICAL FLOOD ANALYSIS** | | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6.2a | **If the IDF is statistically determined, the reliability of existing statistical flood analysis shall be confirmed or a new statistical flood analysis shall be developed** | X | | | | | This report | | | |
| | 6.2b | **If an unusual event has been recorded since the statistical flood was evaluated, or if the duration of the available hydrological data has increased by more than 50%, a new statistical flood analysis shall be carried out.** | X | | | | | This report | No new hydrological events occurred since previous evaluation; data since 2000 reviewed for this report. | | |
| **6.3** | **PROBABLE MAXIMUM FLOOD (PMF)** | | | | | | | | | | |
| | 6.3a | **A Probable Maximum Flood (PMF) study shall consider the most severe "reasonably possible" combination of the following phenomena on the watershed upstream of the structure under study** | N/A | | | | | | IDF < PMF | | |
| | 6.3a.1 | **- Rainstorm;** | N/A | | | | | | | | |
| | 6.3a.2 | **- Snow accumulation;** | N/A | | | | | | | | |
| | 6.3a.3 | **- Melt rate;** | N/A | | | | | | | | |
| | 6.3a.4 | **- Initial basin conditions (e.g. soil moisture, lake and river levels);** | N/A | | | | | | | | |
| | 6.3a.5 | **- Prestorm.** | N/A | | | | | | | | |
| | 6.3b | **When the PMF is identified as the IDF for a particular project, the acceptability of any previous PMF analysis must be confirmed or a new PMF analysis undertaken.** | N/A | | | | | | | | |
| **7.0** | **DISCHARGE FACILITIES** | | | | | | | | | | |
| **7.1** | **FLOW CAPACITY OF HYDRAULIC STRUCTURES** | | | | | | | | | | |
| | 7.1a | **The discharge facilities shall be designed or modified to be capable of passing the IDF, taking into account the routing effect of the reservoir, without the reservoir level infringing on the freeboard established in Section 7.2 for this condition.** | X | | | | | 2000 DSR | | | |
| | 7.1b | **New dams shall be designed such that:** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 7.1b.1 | **- The outflow structure handles ice and debris** | X | | | | | | No reported incidents in the past | | |
| | 7.1b.2 | **- Water conveyance structures resist the anticipated high velocities** | X | | | | | | | | |
| | 7.1b.3 | **- Energy dissipation structures protect the dam during the passages of the IDF** | N/A | | | | | | | | |
| **7.2** | **FREEBOARD** | | | | | | | | | | |
| | 7.2a | **Sufficient freeboard shall be provided so that under all operating conditions, including those during extreme floods or extreme wind conditions the percentage of waves that could overtop the dam is limited to an amount that would not lead to dam failure.** | X | | | | | 2000 DSR | | | |
| | 7.2b | **The maximum reservoir level shall be at or below the top of the impervious core for embankment dams** | X | | | | | | Core of main dam raised | | |
| **7.3** | **OPERATION DURING FLOODS** | | | | | | | | | | |
| | 7.3a | **All discharge facilities shall be operated at all times according to a set of pre-determined rules. The development of such rules shall consider the safe passage of all hydrological events, including the IDI** | X | | | | | Snare Hydro OMS manual | | | |
| | 7.3b | **For new dams, rule curves shall be established for operation during the flood season, such that all floods, including the IDF, can be passed safely.** | N/A | | | | | | Not applicale (not a new dam) | | |
| **7.4** | **OPERATION OF FLOW CONTROL EQUIPMENT** | | | | | | | | | | |
| | 7.4a | **The conditions under which the spillway, discharge facilities and power intake must operate, as well as the level of automation associated with the equipment, shall be determined on a site-specific basis** | X | | | | | Snare Hydro OMS manual | | | |
| | 7.4b | **All flow control equipment shall be designed to be capable of opening and closing under required operating conditions. The required service shall be determined by a site-specific evaluation of requirements.** | X | | | | | | | | |
| **7.5** | **INSTRUMENTATION AND CONTROL** | | | | | | | | | | |
| | 7.5a | **Equipment on Very High and High Consequence structures shall be provided with instrumentation to enable local and/o remote monitoring of conditions at the hydraulic structures** | X | | | | | Snare Hydro OMS manual | | | |
| **7.6** | **EMERGENCY EQUIPMENT** | | | | | | | | | | |
| | 7.6a | **As a minimum, emergency power equipment shall be available for installation in a reasonable amount of time at Very High and High Consequence structures. Otherwise, permanent emergency power equipment shall be installed.** | X | | | | | | Emergency power available to spillway 5B and to intake gate | | |
| | 7.6b | **Controls and instrumentation shall permit operation and monitoring during power outage conditions for Very High and High Consequence structures.** | | X | | | | | | | |
| **8.0** | **GEOTECHNICAL CONSIDERATIONS** | | | | | | | | | | |
| **8.1** | **GEOTECHNICAL INVESTIGATIONS FOR NEW DAMS** | | | | | | | | | | |
| | 8.1a | **Adequate geotechnical investigations shall be carried out on the site selected for a new dam** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 8.1b | **A permanent record or log shall be kept of all inspections, investigation reports, drawings and design reports.** | N/A | | | | | | Ditto | | |
| **8.2** | **EMBANKMENT DAMS AND SOIL FOUNDATIONS** | | | | | | | | | | |
| **8.2.1** | **Monitoring and Instrumentation** | | | | | | | | | | |
| | 8.2.1a | **Sufficient instrumentation for the embankment dam and foundation shall be provided, commensurate with the Consequence Category, so that the performance can be adequately monitored and dam safety can be evaluated.** | X | | | | | | | | |
| | 8.2.1b | **For new dams, sufficient instrumentation shall be provided to adequately monitor the dam and evaluate its performance.** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.2.2** | **Stability and Deformation** | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.2.2a | **The slopes of the dam and the abutment shall be designed so that the dam, foundation and abutments are stable under all stages of construction, reservoir levels and operating conditions.** | | X | | | | | Side Dam 4 and 9B, are low structures designed with conservative slopes. No stability issues identified | | |
| | 8.2.2b | **The slopes of the dam and the abutment shall be designed not to cause unacceptable deformation in the dam or foundation.** | X | | | | | | | | |
| | 8.2.2c | **The stability of reservoir slopes shall be evaluated under seismic loads, heavy rainfall, rapid drawdown and any other conditions, if slope failure could induce waves that pose an unacceptable risk to public safety, the dam or its appurtenant structures.** | X | | | | | | | | |
| | 8.2.2d | **If necessary, such slopes shall be stabilized or the public otherwise protected from the effects of slope failure.** | N/A | | | | | | Condition not applicable | | |
| | 8.2.2e | **Any material stockpiled upstream of a tailings dam shall be maintained in a stable configuration, if it can affect the stability of the dam or its appurtenant structures either directly or by destabilising stored or stockpiled tailings.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| | 8.2.2f | **Sufficient freeboard shall be provided to accommodate expected settlement of the crest and cracks caused by frost action.** | X | | | | | 2000 DSR | Core raised in 2000 to address core settlement. | | |
| **8.2.3** | **Seepage and Drainage Control** | | | | | | | | | | |
| | 8.2.3a | **Filters shall be placed between materials where otherwise significant migration of particles by seepage forces would be possible.** | | X | | | | | Sand filters provided between core and shell material of main dam. | | |
| | 8.2.3b | **Construction of embankments, structural cutoffs and foundation treatment shall be staged such that adequate filters are in place.** | | X | | | | | | | |
| | 8.2.3c | **Filter provisions shall be adequate to accommodate the movements and avoid erosion induced by the design earthquake.** | | X | | | | | Dam stable under low seismic loading | | |
| | 8.2.3d | **The hydraulic gradients in the dam, in foundation abutments and along conduits, shall be low enough to prevent piping and heave in the existing material.** | | | | X | | | Stability to be checked wrt seepage associated with sub-horizontal joint in power tunnel | | |
| | 8.2.3e | **The flow capacity of filters and drains shall be designed to accommodate the maximum anticipated seepage.** | | X | | | | | Shells of the dam are rockfill and likely free draining. | | |
| **8.2.4** | **Cracking** | | | | | | | | | | |
| | 8.2.4a | **The dam shall be designed to retain the reservoir safely in spite of any cracking that may be induced by settlement or hydraulic fracturing.** | X | | | | | | There is no evidence that excessive settlement or hydraulic fracturing has occurred. Cracks have not been identified in the past. | | |
| **8.2.5** | **Surface Erosion** | | | | | | | | | | |
| | 8.2.5a | **The upstream slopes of the dam and its abutments shall be provided with adequate protection to guard against erosion and possible breaching due to wave and ice action and against burrowing animals such as beaver and muskrat. Failure of riprap must not result in dam failure.** | X | | | | | | | | |
| | 8.2.5b | **The downstream slopes shall be protected where necessary against the erosive action of runoff, seepage flows, traffic, frost and burrowing animals.** | X | | | | | | | | |
| | 8.2.5c | **Inlet and outlet channels for spillways and conduits shall be adequately protected against erosior** | X | | | | | | Spillway excavated in rock. | | |
| | 8.2.5d | **Temporary and permanent slopes of the embankments and abutments shall be adequately protected against wave action, runoff and seepage flows during construction** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.2.6** | **Liquefaction** | | | | | | | | | | |
| | 8.2.6a | **All embankment and foundation materials susceptible to liquefaction shall be identifiec** | N/A | | | | | | | | |
| | 8.2.6b | **If liquefaction is possible under static conditions or probable under design earthquake loading, the post-liquefaction stability of the dam shall be evaluated.** | N/A | | | | | | | | |
| | 8.2.6c | **If unacceptable flowsliding is probable following liquefaction, appropriate remedial measures shall be undertaken to ensure dam failure does not occur.** | N/A | | | | | | | | |
| **8.2.7** | **Earthquake Resistance** | | | | | | | | | | |
| | 8.2.7a | **The dam, appurtenant structures, foundation and abutments shall be designed to resist the forces associated with the Maximum Design Earthquake (MDE).** | | X | | | | 2000 DSR, this report. | Intake stability not assessed. | | |
| | 8.2.7b | **Embankments and foundations that are required to impound temporary reservoirs during construction shall be designed to resist forces associated with the MDE selected for their desigr** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.3** | **DAMS ON ROCK FOUNDATIONS** | | | | | | | | | | |
| **8.3.1** | **Foundation Stability** | | | | | | | | | | |
| | 8.3.1a | **For new dams rock foundations shall be excavated to a depth, and grouted, such that they have sufficient strength, watertightness and stiffness:** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 8.3.1a.1 | **- to support all stages of construction and initial reservoir filling and drawdowı** | N/A | | | | | | Ditto | | |
| | 8.3.1a.2 | **- to provide adequate stability under design loads for the dam, appurtenances, abutments and foundatior** | N/A | | | | | | Ditto | | |
| | 8.3.1a.3 | **- to limit deformations to acceptable values.** | N/A | | | | | | Ditto | | |
| **8.3.2** | **Shear Strength Parameters** | | | | | | | | | | |
| | 8.3.2a | **The dam shall be designed such that the shear strength of the rock foundations is adequate at all stages of construction, initial reservoir filling and drawdown, to ensure the stability of a dam at and within its foundation.** | | | | X | | | Stability of Main Dam rock foundation requires analysis acounting for sub horizontal joint in the power tunnel. | | |
| **8.3.3** | **Seepage and Drainage** | | | | | | | | | | |

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.3.3a | **If the rock is not of sufficient quality, adequate protection shall be provided to protect against internal erosion, leaching, or solution effects in foundations or abutments.** | | X | | | | | Satisfactory operating history (40 years) of dam indicates that foundation is adequate. | | |
| | 8.3.3b | **The foundation and abutment grouting and drainage systems shall maintain foundation water pressures at acceptable levels.** | N/A | | | | | | No grouting or drainage of bedrock are shown on drawings. | | |
| | 8.3.3c | **Where embankments are constructed on rock foundations, the treatment of the foundation shall be compatible with the embankment materials, such that migration of the embankment material is prevented.** | | X | | | | | No foundation treatment shown on drawings. Satisfactory performance indicates adequate treatment. | | |
| | 8.3.3d | **Provision shall be made to control unacceptable quality and quantity of seepage for all stages of construction, initial reservoir filling, operation and drawdown**. | | X | | | | | Satisfactory performance indicates adequate control. | | |
| 8.4 | **DAMS ON PERMAFROST** | | | | | | | | | | |
| | 8.4a | **Dams on permafrost shall meet the same stability requirements as other embankment dams, and shall remain stable in spite of large foundation settlements.** | | X | | | | | Side Dam 4 and 9B, have satisfactory performance history despite settlement. | | |
| | 8.4b | **The freeboard shall be adequate to accommodate the expected settlement.** | | X | | | | | Side Dam 4 and 9B require periodic topping up to to meet freeboard requirements. Surveys required to determine design level is achieved. | | |
| | 8.4c | **The fill zones shall have sufficient integrity to prevent piping and limit seepage to an acceptable amount.** | | X | | | | | Homogeneous Side Dams 4 and 9B have no observable seepage. | | |
| 8.5 | **APPURTENANT STRUCTURES** | | | | | | | | | | |
| 8.5.1 | **Foundation Movement** | | | | | | | | | | |
| | 8.5.1a | ***In situ* foundations and abutments as well as embankments and backfill, through which or on which an appurtenant hydraulic structure will be constructed, should be designed to be free from gravity-driven movements that would impair the operational capability of the structure or lead to structural damage such as excessive cracking, deformation, deflection, damage to joints, threaten the structural integrity and hydraulic performance. Likewise, the foundations and embankment shall be protected from any potential adverse effects of any leakage from any conduit or structures.** | | X | | | | | No record of movements of appurtenant structures or abutments. | | |
| | 8.5.1b | **The foundation of an appurtenant hydraulic structure, whether *in situ* or compacted earthen materials, shall be designed to avoid differential settlement or heave that would either damage seals, waterstops or joints, or misalign or crack slabs or monoliths** | | X | | | | | Intake structure constructed on bedrock. | | |
| 8.5.2 | **Slope Stability** | | | | | | | | | | |
| | 8.5.2a | **Slopes flanking the approach and exit channels of an appurtenant hydraulic structure shall be designed to be stable to the extent that any instability under the broad category of gravity-driven soil and rock movement does not restrict these channels.** | X | | | | | | Retaining wall along right abutment of Spillway 5B satisfactory. Intake is flanked by Main dam slopes. | | |
| 8.5.3 | **Seepage** | | | | | | | | | | |
| | 8.5.3a | **The impervious or seepage-control zone immediately underlying or enclosing the upstream portion of an appurtenant hydraulic structure, including components such as cut-off, core trench or upstream blanket shall be designed to be free of localised concentrations of seepage that could lead to piping. In the case of new dams, this impervious or seepage-control zone shall be free of deleterious hydraulic and material conditions which individually or in combination could lead to excessive seepage and piping** | | X | | | | | Performance record indicates adequate seepage control at control structures. | | |
| 8.6 | **GABION, ROCK CRIB AND TIMBER STRUCTURES** | | | | | | | | | | |
| | 8.6a | **Gabion, rock crib and timber dams, and their foundations, shall meet the same stability requirements as all dams. In addition, the timber shall maintain durability and be capable of transmitting the induced loads.** | | X | | | | | Timber crib retaining wall along right abutment of Spillway 5B satisfactory based on performance record. | | |
| | 8.6b | **Gabion dams shall incorporate a suitable filter as a preventive measure against undermining of the foundation soil material. The wire comprising the gabion mesh shall be adequately sized and protected against corrosion and shall be designed to retain its integrity for the planned life of the structure** | N/A | | | | | | | | |
| 8.7 | **MEMBRANE-FACED ROCKFILL DAMS** | | | | | | | | | | |
| | 8.7a | **Membrane-faced rockfill dams and their foundations shall meet the same stability requirements as other embankment dams. The integrity of the upstream membrane shall be designed to minimize the effects of settlement, ultraviolet deterioration and any other damage that would permit excessive leakage.** | N/A | | | | | | Not a membrane faced rockfill dam. | | |
| | 8.7b | **Seepage or leakage through the membrane face shall be limited to values that will not adversely affect dam stability.** | N/A | | | | | | | | |
| 8.8 | **FLOW-THROUGH ROCKFILL DAMS** | | | | | | | | | | |
| | 8.8a | **For the design flood, flow-through rockfill dams shall be designed to withstand the combined effects of the action of the seepage emerging from the downstream face, along with any overflow without local or massive movement of rock particles.** | N/A | | | | | | Not a flow through Rockfill dam | | |
| 9.0 | CONCRETE STRUCTURES | | | | | | | | | | |
| 9.1 | **GENERAL** | | | | | | | | | | |
| | 9.1a | **The level of design or safety assessment for concrete dams and other water-retaining structures shall take into account the consequences of failure of the structure.** | | | | X | | 2000 DSR, this report | Intake stability not assessed, Spillway 5B stability not assessed | Insufficient data available to KCBL | Intake stability assessment required, Spillway 5B stability assessment required |

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **9.2** | | **CONDITION OF STRUCTURES AND SITES** | | | | | | | | | |
| | **9.2a** | **The strength and condition of the dam and foundation shall be determined to the extent required for the design of a new dam or analysis of an existing dam.** | | | | **X** | | | See 9.1a | | |
| | **9.2b** | **If the concrete appears to be damaged or weakened, tests shall be carried out to determine its strength parameters, or suitably conservative assumptions made in the analysis of its safety.** | **X** | | | | **X** | 2000 DSR, this report | Condition of Intake Structure is acceptable. Spillway 5B Bays 3 & 4 have major cracks adjacent to gains. Bays 3 to 5 have undercut piers at downstream ends. | Repairs to cracked concrete adjacent to the gains was recommended in 2000 DSR but this was not done. | Spillway 5B requires repairs Priority H |
| | **9.2c** | **For High and Very High Consequence dams, sufficient instrumentation shall be provided for the structure and foundation, to allow performance to be monitored and safety to be evaluated.** | **X** | | | | | | Instrumentation of Intake Structure is not considered necessary. | | |
| **9.3** | | **LOADS** | | | | | | | | | |
| | **9.3a** | **The following loads shall be considered in the design or assessment of concrete structures** | | | | **X** | | | See 9.1a | | |
| | **9.3a.1** | **- Dead loads of permanent structures and equipment (D);** | | | | **X** | | | See 9.1a | | |
| | **9.3a.2** | **- Maximum normal headwater level (H) combined ,with the most critical concurrent tailwater level** | | | | **X** | | | See 9.1a | | |
| | **9.3a.3** | **- Maximum flood headwater level ($H_F$) based on the Inflow Design Flood (IDF) with corresponding tailwater levels;** | | | | **X** | | | See 9.1a | | |
| | **9.3a.4** | **- Internal water pressure and foundation uplift (U);** | | | | **X** | | | See 9.1a | | |
| | **9.3a.5** | **- Static and dynamic thrust created by an ice sheet, for reservoirs subject to freezing (I)** | | | | **X** | | | See 9.1a | | |
| | **9.3a.6** | **- Vertical and horizontal loading due to rock or soil backfill, including potential effects of liquefaction, as well as loads from silt deposited against the structure (S);** | | | | **X** | | | See 9.1a | | |
| | **9.3a.7** | **- Maximum Design Earthquake (Q);** | | | | **X** | | | See 9.1a | | |
| | **9.3a.8** | **- Temperature-induced loads (T), for stability and stress analysis of concrete structures with grouted contraction joints, especially buttress and arch dams.** | | | | | | **N/A** | | | |
| **9.4** | | **LOAD COMBINATIONS** | | | | | | | | | |
| **9.4.1** | | **Usual Loading** | | | | | | | | | |
| | **9.4.1a** | **Permanent and operating loads shall be considered for both summer and winter conditions including self-weight, ice, silt, earth pressure, and the normal maximum operating water level with appropriate uplift pressures and tailwater level (D+H+I+S+U).** | | | | **X** | | | See 9.1a | | |
| **9.4.2** | | **Unusual Loading** | | | | | | | | | |
| | **9.4.2a** | **Where earthquake-induced cracking at the rock concrete interface or any weak section is identified, a stability analysis shall be carried out to see whether the structure in its post-earthquake condition is still capable of resisting the Usual Loading (D+H+S+$U_{PO}$).** | | | | **X** | | | See 9.1a | | |
| **9.4.3** | | **Flood Loading** | | | | | | | | | |
| | **9.4.3a** | **Permanent and operating loads of the Usual Loading, except for ice loading, shall be considered in conjunction with reservoir and tailwater levels and uplift resulting from the passage of the Inflow Design Flood (IDF) (D+H+S+$U_F$).** | | | | **X** | | | See 9.1a | | |
| **9.4.4** | | **Earthquake Loading** | | | | | | | | | |
| | **9.4.4a** | **Permanent and operating loads of the Usual Loading case shall be considered in conjunction with the seismic loads of the Maximum Design Earthquake (MDE) (D+H+S+Q+$U_Q$).** | | | | **X** | | | See 9.1a | | |
| **9.4.5** | | **Temperature Loading** | | | | | | | | | |
| | **9.4.5a** | **Permanent and operating loads from the Usual Loading case shall be considered in conjunction with temperature loads for buttress and arch dams (D+H+I+S+U+T).** | **N/A** | | | | | | | | |
| **9.5** | | **DESIGN AND ANALYSIS** | | | | | | | | | |
| | **9.5a** | **Concrete dams shall be designed to resist and prevent** | | | | **X** | | | See 9.1a | | |
| | **9.5a.1** | **- Sliding at the dam-foundation interface, within the dam and at any plane in the foundation** | | | | **X** | | | See 9.1a | | |
| | **9.5a.2** | **- Overturning;** | | | | **X** | | | See 9.1a | | |
| | **9.5a.3** | **- Overstressing of the concrete dam or foundation;** | | | | **X** | | | See 9.1a | | |
| | **9.5a.4** | **- Excessive seepage through the foundation or through joints in the concrete dam** | | | | **X** | | | See 9.1a | | |
| | **9.5b** | **Safety analyses for existing concrete dams shall take into account their ability to resist and prevent the above conditions.** | | | | **X** | | | See 9.1a | | |
| | **9.5c** | **Stresses and stability of a concrete gravity dam shall be evaluated for ground motions in the upstream-downstream direction. If the geometry suggests potential "pounding" of adjacent blocks, cross-valley analyses shall be undertaken.** | | | | **X** | | | See 9.1a | | |
| | **9.5d** | **Stresses and stability of a buttress dam shall be evaluated for ground motions in the upstream-downstream as well as the cross-valley directions** | | | | | | | | | |
| **9.6** | | **PERFORMANCE INDICATORS** | | | | | | | | | |
| | **9.6a** | **The design and assessment of concrete dams and other water-retaining structures shall be based on performance indicators such as:** | | | | **X** | | | See 9.1a | | |
| | **9.6a.1** | **- Position of resultant force;** | | | | **X** | | | See 9.1a | | |
| | **9.6a.2** | **- Normal stresses at the heel and the toe;** | | | | **X** | | | See 9.1a | | |
| | **9.6a.3** | **- Average shear stresses acting on the surface** | | | | **X** | | | See 9.1a | | |
| | **9.6a.4** | **- Calculated sliding factors and strength factors;** | | | | **X** | | | See 9.1a | | |
| | **9.6a.5** | **- Observed conditions of structure and site** | **X** | | | | | 2000 DSR, this report | | | |
| **9.7** | | **ACCEPTANCE CRITERIA** | | | | | | | | | |

## Table 14-2: 2006 Dam Safety Review
## Conformance of Snare Rapids with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.7a | **Concrete gravity, buttress and arch dams and their foundations shall have adequate sliding resistance to withstand all reasonable loads and load combinations that could occur** | | | | X | | | See 9.1a | | |
| | 9.7b | **The concrete must have sufficient strength that the loads will not result in excessive deformations or overstressing.** | | | | X | | | See 9.1a | | |
| | 9.7c | **During and after extreme events such as the IDF and the MDE, the dam shall continue to safely retain the reservoir water.** | | | | X | | | See 9.1a | | |
| | 9.7d | **The level of safety of appurtenant structures shall be compatible with the consequences of their failure.** | N/A | | | | | | No concrete appurtenance structures governed by DSR requirements | | |
| | 9.7e | **The effects of static and dynamic (seismic) loadings on support structures for mechanical and electrical equipment that relate to dam safety shall be examined to ensure that structural integrity and functionality are preserved.** | | X | | | | | Not assessed but MDE is low | | |
| 9.8 | ROLLER-COMPACTED CONCRETE (RCC) DAMS | | | | | | | | | | |
| | 9.8a | **Roller-compacted concrete (RCC) dams shall meet the same stability and performance specifications as conventional concrete gravity dams.** | N/A | | | | | | Not an RCC Dam | | |
| 10.0 | RESERVOIR AND ENVIRONMENT | | | | | | | | | | |
| 10.1 | RESERVOIR DEBRIS AND ICE | | | | | | | | | | |
| | 10.1a | **Reservoir debris and ice shall be managed in such a way that they do not constitute an unacceptable risk to dam safety.** | X | | | | | | Performance record indicates adequate debris and ice management. | | |
| 10.2 | RESERVOIR RIM | | | | | | | | | | |
| | 10.2a | **Unstable slopes or slopes which are potentially unstable under extreme loading, or rapid reservoir drawdown condition around the reservoir rim shall be monitored and treated if necessary so that they do not constitute an unacceptable risk to the safety of the dam.** | N/A | | | | | | | | |
| | 10.2b | **Any point on the rim of the reservoir which forms a natural barrier shall be treated in the same manner as a dam, if its failure could release the reservoir** | N/A | | | | | | | | |
| | 10.2c | **Excessive seepage through the reservoir rim shall be controlled so that it does not constitute an unacceptable risk to the safety of the dam or reservoir.** | N/A | | | | | | | | |
| 10.3 | WATER QUALITY | | | | | | | | | | |
| | 10.3a | **Consideration shall be given to monitoring detrimental effects on structural elements of the dam from chemical interaction between groundwater, reservoir water, natural soil, and all dam materials, and to taking necessary protective measures.** | | X | | | | | No report of water quality issue in many years of operation. | | |
| 10.4 | SEDIMENTATION AND SILTING | | | | | | | | | | |
| | 10.4a | **Silt deposition near the dam and discharge facilities shall be monitored as appropriate and if the continued deposition could impair the safe routing of floods or the stability of the dam, appropriate remedial measures shall be taken.** | | X | | | | | No evidence of siltation at any structure. | | |
| | 10.4b | **Tailings shall not be deposited in such a manner as to hinder the operation or stability of a dam and its appurtenant structures.** | N/A | | | | | | Not applicable (not a tailings dam). | | |
| 10.5 | RESERVOIR DRAWDOWN CAPABILITY | | | | | | | | | | |
| | 10.5a | **At dams that are subject to severe damage by earthquake or landslides, or where a high potential for internal erosion exists, outlet facilities shall be provided to quickly lower the reservoir to a safe level for the dam in its damaged state.** | N/A | | | | | | | | |
| 10.6 | ECOLOGY | | | | | | | | | | |
| | 10.6a | **The dam shall be monitored for dam safety hazards presented by animals, birds, vegetation or other organisms, and protective action taken if required.** | | X | | | | | Maintenance required locally to remove vegetation. | | |
| 10.7 | REHANDLING OF TAILINGS | | | | | | | | | | |
| | 10.7a | **The rehandling of tailings or other materials upstream of, or adjacent to a dam, shall be undertaken in such a manner that the safety or safe operation of a dam and appurtenances is not impaired.** | N/A | | | | | | Not a tailings facility | | |
| 11.0 | CONSTRUCTION | | | | | | | | | | |
| | 11a | **An Engineer shall ensure that the project specifications are strictly adhered to. Any deviation from the prescribed specifications are allowed only if approved by the design engineer** | N/A | | | | | | Not a new dam. | | |
| | 11b | **The Engineer shall document and approve all phases of the project construction** | N/A | | | | | | Ditto | | |
| | 11c | **Temporary construction facilities shall be constructed such that there is no adverse impact on the safety of the dam or appurtenant structures.** | N/A | | | | | | Ditto | | |

# Table 14-3: 2006 Dam Safety Review
# Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** **procedural, operational or maintenance aspect.**

**DEFICIENCY =** **aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | . | | | | | | | | | | |
| **1.0** | **SCOPE, DEFINITIONS AND GENERAL REQUIREMENTS** | | | | | | | | | | |
| **1.1** | **SCOPE AND APPLICABILITY OF THE GUIDELINES** | | | | | | | | | | |
| **1.2** | **DEFINITIONS** | | | | | | | | | | |
| **1.3** | **RESPONSIBILITY FOR DAM SAFETY** | | | | | | | | | | |
| **1.3.1** | **General** | | | | | | | | | | |
| | **1.3.1a** | **The responsibility for all aspects of the safety of a dam shall be clearly defined and delegation of responsibility and authority shall be documented.** | | | **X** | | | Snare OMS and EPP manuals | Updating and reorganization of the manuals is required. | | |
| **1.4** | **CLASSIFICATION OF DAMS** | | | | | | | | | | |
| | **1.4a** | **Each dam, water control structure or water passage, shall be classified in terms of the reasonably foreseeable incremental consequences of failure.** | **X** | | | | | | | | |
| | **1.4b** | **The loss of life consequences shall be evaluated separately from the socioeconomic, financial and environmental consequences and the higher of the two classifications shall be used.** | **X** | | | | | | | | |
| | **1.4c** | **For new dams, the consequences category shall be established during feasibility studies used for design, and confirmed prior to first reservoir filling.** | **N/A** | | | | | Not a new dam | | | |
| **1.5** | **SELECTION OF SAFETY CRITERIA** | | | | | | | | | | |
| | **1.5a** | **The dam, along with its foundation and abutments, shall be designed to have adequate stability to safely withstand extreme loads as well as the normal design loads.** | **X** | | | | | | | | |
| | **1.5b** | **The selection of loading criteria for extreme loads shall be based on the consequences of failure of the dam** | **X** | | | | | | | | |
| | **1.5c** | **For tailings dams, the loading criteria or level of safety at any stage of construction shall be commensurate with the consequences of failure at that stage , with due consideration of the consequences at future stages** | **N/A** | | | | | | Not a tailings dam | | |
| **1.6** | **DECOMMISSIONING AND CLOSURE** | | | | | | | | | | |
| | **1.6a** | **A dam shall be decommissioned and considered closed only when all the requirements of a decommissioning plan hav been complied with.** | **N/A** | | | | | | Not applicable (dam is still in full operation). | | |
| | **1.6b** | **Demolition of a dam or removal of any of its appurtenances shall be based on sound practice and carried out without increasing the risk of failure of remaining structures and appurtenances or causing adverse impacts downstream of the dam.** | **N/A** | | | | | | Ditto | | |
| | **1.6c** | **Demolition operations shall not result in blockage or reduction of the safe discharge of natural floods. That part of the dam and its appurtenant structures which may obstruct the discharge of the water course or drainage course such that it causes upstream flooding beyond that of the existing dam and appurtenent structures or leads to a sudden release of water, must be completely removed.** | **N/A** | | | | | | Ditto | | |
| | **1.6d** | **Structures that remain after decommissioning shall be physically and chemically stable, and shall not impose an unacceptable risk to public health and safety, or the environment** | **N/A** | | | | | | Ditto | | |
| | **1.6e** | **Closure requirements for tailings dams must be considered and incorporated into the initial design stage and at all subsequent design and construction phases** | **N/A** | | | | | | Ditto | | |
| | **1.6f** | **Any tailings dam that retains contaminated or acid generating materials shall be monitored and maintained, to a level commensurate with the consequences of failure, after infilling is completed or mining operations are terminated.** | **N/A** | | | | | | Ditto | | |
| **2** | **DAM SAFETY REVIEW** | | | | | | | | | | |
| **2.1** | **GENERAL** | | | | | | | | | | |
| | **2.1a** | **A Dam Safety Review (the "Review") shall be carried out by a qualified engineer (the "Engineer") at regular time intervals for dams and associated facilities. The review shall include the design, operation, maintenance, surveillance and emergency plans, to determine if they are safe in all respects and, if they are not, to determine required safety improvements.** | **X** | | | | | | | | |
| | **2.1b** | **The first Dam Safety Review for a new dam shall be completed within three years of initial filling** | **N/A** | | | | | | Not the first DSR | | |
| | **2.1c** | **A Dam Safety Review shall be carried out when there are significant changes in the stage of construction of a tailings dam, or the condition of any dam, including:** | **N/A** | | | | | | See individual comments below | | |
| | **2.1c.1** | **- Major modification to the original design or design criteria** | **N/A** | | | | | | | | |
| | **2.1c.2** | **- Discovery of an unusual condition;** | **N/A** | | | | | | Not applicable (no unusual condition prior to DSR) | | |
| | **2.1c.3** | **- Decommissioning;** | **N/A** | | | | | | Not applicable (facility still in full operation). | | |
| | **2.1c.4** | **- After an extreme hydrological or seismic event.** | **N/A** | | | | | | Not applicable (no extreme hydrological or seismic events). | | |
| **2.2** | **DETAILS OF REVIEW** | | | | | | | | | | |
| **2.2.1** | **Dam Classification** | | | | | | | | | | |
| | **2.2.1a** | **The Review shall include the classification of the dam, as outlined in Section 1.** | **X** | | | | | | | | |
| **2.2.2** | **Site Inspection** | | | | | | | | | | |
| | **2.2.2a** | **The Review shall include an appropriately comprehensive field inspection of the dam and appurtenant structures, and documentation thereof.** | **X** | | | | | | | | |
| **2.2.3** | **Design and Construction** | | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

# Table 14-3: 2006 Dam Safety Review
## Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** **procedural, operational or maintenance aspect.**

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| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.2.3a | **The Review of design and construction shall be sufficiently comprehensive to demonstrate whether the dam, discharge facilities and reservoir slopes meet all currently applicable safety requirements** | | | X | | | | Inake stability not reviewed, inadequate drawings available. | | |
| **2.2.4** | **Operation and Testing** | | | | | | | | | | |
| | 2.2.4a | **The Review shall determine if safe operating procedures have been developed, documented and followed in all respects. The adequacy of the documentation shall be reviewed** | X | | | | | Snare Hydro OMS manual | | | |
| | 2.2.4b | **The Review shall include the testing of equipment required to operate discharge facilities (including backup equipment and emergency power supply) that are required for the safe passage of the inflow design flood, and any other flood that could endanger the dam, and adequacy of ice and debris control facilities and procedures to verify that they will function as and when required.** | | | | X | | | Discharge equipment is tested annually during station annual outage, but test records not provided. | | |
| **2.2.5** | **Maintenance** | | | | | | | | | | |
| | 2.2.5a | **The Review shall ascertain if all facilities required for safety of the dam, including dam monitoring instrumentation, are maintained in satisfactory condition in accordance with a manual defining the maintenance requirements for dam safety.** | | | | X | | | No inspection or maintenance records provided | | |
| **2.2.6** | **Surveillance and Monitoring of Dam Performance** | | | | | | | | | | |
| | 2.2.6a | **The Review shall determine if the surveillance and monitoring methods and frequency are adequate to detect any unsafe condition in a timely manner.** | X | | | | | | | | |
| | 2.2.6b | **The Review shall determine if monitoring data have been regularly analysed and used to ensure prompt detection of any potentially unsafe conditions in the dam, associated water containment and reservoir slopes.** | | | | X | | | No documentation available showing analysis of dam safety monitoring measurements or test results of operating equipment | | |
| **2.2.7** | **Emergency Preparedness** | | | | | | | | | | |
| | 2.2.7a | **The Review shall determine if the appropriate level of emergency preparedness exists and is adequately documented. The adequacy of warning systems, training and emergency response plans shall be reviewed, as well as testing and updating of plans.** | | | X | | | Snare Hydro EPP manual | Updating required. See report for specifics. | | |
| **2.2.8** | **Compliance with Previous Reviews** | | | | | | | | | | |
| | 2.2.8a | **Previous Dam Safety Reports shall be reviewed to determine compliance with their recommendations.** | | | X | | | This report | Gate skin plate thickness and structural strength check not performed | | Check plate thickness and assess structural strength. |
| **2.3** | **DAM SAFETY REPORT** | | | | | | | | | | |
| | 2.3a | **A Dam Safety Report ("the Report"), covering all aspects of the dam's safety, shall be prepared, documenting the Dam Safety Review.** | X | | | | | | | | |
| | 2.3b | **The Report shall identify any additional steps required for the safe operation, maintenance and adequate surveillance of the dam.** | X | | | | | | | | |
| **2.4** | **FAILURE TO MEET REQUIREMENTS** | | | | | | | | | | |
| | 2.4a | **If the dam and/or appurtenant structures fails to meet the safety requirements, safety improvements shall be carried out as appropriate, including:** | | | | | | | | | |
| | 2.4a.1 | **- Safety improvements of the physical facilities;** | | | X | | | | See Table 14.1 | | |
| | 2.4a.2 | **- Nonstructural improvements;** | | | X | | | | See Table 14.1 | | |
| | 2.4a.3 | **- Overcoming any deficiencies in operation, surveillance, inspection or maintenance of the dam, or emergency preparedness.** | | | X | | | | See Table 14.1 | | |
| **3.0** | **OPERATION, MAINTENANCE AND SURVEILLANCE** | | | | | | | | | | |
| **3.1** | **GENERAL** | | | | | | | | | | |
| | 3.1a | **Dam operation, maintenance and surveillance shall be provided so that an acceptable level of dam safety is ensured.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.1b | **A manual (the "OMS Manual") shall be prepared, documenting operation, maintenance and surveillance for each applicable dam. The OMS manual shall be implemented, followed, and updated at appropriate intervals. The manual shall contain suitable and sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition, and monitor its performance well enough to provide early signs of any distress.** | | | X | | | | Updating required. Refer to report for specifics. | | |
| | 3.1c | **For tailings dams a separate OMS Manual shall be prepared for the closure stage or included in the decommissioning plan.** | N/A | | | | | | Not Applicable (not a tailings dam) | | |
| | 3.1d | **Qualified personnel shall be used for the operation, maintenance and surveillance of a dam.** | | X | | | | | No documentation defining training and qualifications for operators relating to dam safety. | | |
| | 3.1e | **Adequate records shall be maintained.** | | | | X | | | Station operating log is maintained but no documentation of maintenance or testing is available | | |
| **3.2** | **OPERATION** | | | | | | | | | | |
| **3.2.1** | **Design Information** | | | | | | | | | | |
| | 3.2.1a | **The operation of the dam shall not violate any important design assumptions that could impair the safety of the dam.** | X | | | | | | | | |
| **3.2.2** | **Flood Operating Procedures** | | | | | | | | | | |
| | 3.2.2a | **During the flood season, a sufficient number or capacity of gates and facilities necessary for discharging flows up to the Inflow Design Flood (IDF) shall be maintained in operable condition** | X | | | | | Snare Hydro OMS manual | | | |

## Table 14-3: 2006 Dam Safety Review
## Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** **procedural, operational or maintenance aspect.**

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| | 3.2.2b | **Procedures for safe operation and any restrictions for gate operation shall be documented. The procedures shall list all operating restrictions, including drawdown so that any flows up to and including the IDF can be routed in a safe and consistent manner.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.2.2c | **The reservoir shall be operated in accordance with the documented procedures** | X | | | | | Snare Hydro OMS manual | | | |
| **3.2.3** | **Emergency Operating Procedures** | | | | | | | | | | |
| | 3.2.3a | **Procedures for reservoir control and discharge in the case of a developing breach or potential breach, and for any emergency drawdown of the reservoir shall be established.** | X | | | | | | Underflow Spillway gates provide the means to drawdown the reservoir, combined with reducing the inflow from upstream. | Saddle Dam 1 has been lowered as an improvement to act as an emergency fuseplug spillway if required. | |
| **3.2.4** | **Ice and Debris Handling** | | | | | | | | | | |
| | 3.2.4a | **Where reservoirs can contain significant quantities of ice or debris, procedures shall be established for safely handling ice and/or debris.** | | | X | | | | No procedure in evidence | | |
| **3.2.5** | **Flood Forecasting** | | | | | | | | | | |
| | 3.2.5a | **The source of any flood forecasting information shall be identified** | X | | | | | | | | |
| **3.2.6** | **Water Balance for Tailings Basins** | | | | | | | | | | |
| | 3.2.6a | **For tailings basins, the water balance shall be reviewed on a periodic basis, at least annually, to ensure safe operation during flood or drought conditions** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **3.3** | **MAINTENANCE** | | | | | | | | | | |
| | 3.3a | **Maintenance policies, procedures, records and responsibilities shall be developed and implemented to ensure that the dam, together with applicable structures and equipment required for flood discharge, is maintained in a safe and fully operable condition.** | | | X | | | Snare Hydro OMS manual | Responsibility for dam safety currently not defined | | |
| | 3.3b | **All Equipment related to dam safety shall be inspected and tested at regular intervals to ensure safe and reliable operation.** | X | | | | | | | | |
| **3.4** | **SURVEILLANCE** | | | | | | | | | | |
| **3.4.1** | **Standards** | | | | | | | | | | |
| | 3.4.1a | **Standards shall be established for each dam to cover inspections, monitoring of fluid-retaining structures, and testing of discharge facilities.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.4.1b | **The level of surveillance shall be based on the Consequence classification of the dam** | X | | | | | | | | |
| **3.4.2** | **Regular Inspections** | | | | | | | | | | |
| | 3.4.2a | **In order to obtain baseline data, an initial inspection shall be performed on a new dam prior to the commencement of initial filling** | N/A | | | | | | Not a new dam | | |
| | 3.4.2b | **Periodic inspections shall be performed to determine the condition of integral portions of the fluid-retaining structure.** | | | | X | | | OMS manual specifies frequent inspections but inspection records were not available for review. | | |
| | 3.4.2c | **Appropriate investigations, as outlined in Section 2, shall be undertaken of all potential deficiencies disclosed by the regular inspections** | X | | | | | | | | |
| | 3.4.2d | **Annual inspections shall be made of all operating tailings dams** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **3.4.3** | **Special Inspections** | | | | | | | | | | |
| | 3.4.3a | **Special inspections shall be performed following potentially damaging events.** | N/A | | | | | | No known potentially damaging events have occurred | | |
| **3.4.4** | **Instrumentation** | | | | | | | | | | |
| | 3.4.4a | **Initial readings of all instruments shall be made and formalized as baseline data** | N/A | | | | | | No instrumentation | | |
| | 3.4.4b | **Instrumentation shall be monitored, evaluated and maintained, and the data shall be compared with the previous readings and expected design values** | N/A | | | | | | Ditto | | |
| **3.4.5** | **Tests** | | | | | | | | | | |
| | 3.4.5a | **All operating equipment and facilities necessary to pass the IDF shall be inspected and tested annually to ensure that they will function as required.** | X | | | | | | Intake and spillway equipment is inspected and tested annually in accordance with OMS manual. | | |
| **4.0** | **EMERGENCY PREPAREDNESS** | | | | | | | | | | |
| **4.1** | **GENERAL** | | | | | | | | | | |
| | 4.1a | **Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken.** | X | | | | | Snare Hydro Emergency Preparedness Plan | | | |
| | 4.1b | **An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage.** | X | | | | | | | | |
| | 4.1c | **A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.** | X | | | | | | The notification process received an operational test in 2006 when Freeboard Dyke 1 near Snare Falls failed due to overtopping. | | |
| | 4.1d | **Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.** | | | | X | | | | | |
| **4.2** | **EMERGENCY PREPAREDNESS PLAN** | | | | | | | | | | |
| **4.2.1** | **Development of an EPP** | | | | | | | | | | |

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## Conformance of Snare Falls with CDA Dam Safety Guidelines

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.2.1a | **An EPP shall describe the actions to be taken by the dam owner and operator in an emergency. The EPP shall assign responsibility for each action to an individual (identified by organizational position) and/or backup.** | | | | X | | Snare Hydro Emergency Preparedness Plan | The notification process received an opertional test in 2006 when a saddle dyke failed due to overtopping near Snare Forks. The process did not work in time to prevent the breach. | | |
| | 4.2.1b | **Input from, and interfaces with, other agencies and affected parties shall be included in the EPP, as appropriate.** | | | | X | | | Affected parties and positions not adequately presented in EPP. | | |
| | 4.2.1c | **Copies of the EPP, or summaries of relevant information shall be provided to those who have responsibilities under the plan.** | | | | X | | | Distribution of the EPP is not controlled. | | |
| **4.2.2** | **Contents of an EPP** | | | | | | | | | | |
| | 4.2.2a | **The EPP shall include the following procedures and information** | | | | | | | | | |
| | 4.2.2a.1 | **- Emergency notification and evaluation;** | | | | X | | | Needs updating and better organization | | |
| | 4.2.2a.2 | **- Preventative actions (where available);** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.3 | **- Notification procedure;** | | | | X | | | Needs updating and better organization | | |
| | 4.2.2a.4 | **- Notification flowchart;** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.5 | **- Communication systems;** | X | | | | | | | | |
| | 4.2.2a.6 | **- Access to site;** | X | | | | | | | | |
| | 4.2.2a.7 | **- Response during periods of darkness;** | X | | | | | | | | |
| | 4.2.2a.8 | **- Response during periods of adverse weather;** | X | | | | | | | | |
| | 4.2.2a.9 | **- Sources of equipment;** | | X | | | | | | | |
| | 4.2.2a.10 | **- Stockpiling supplies and materials;** | | X | | | | | | | |
| | 4.2.2a.11 | **- Emergency power sources, if required;** | X | | | | | | | | |
| | 4.2.2a.12 | **- Inundation maps;** | | | | X | | | Add inundation maps | | |
| | 4.2.2a.13 | **- Warning systems (if used).** | | X | | | | | | | |
| **4.2.3** | **Maintenance and Testing of the EPP** | | | | | | | | | | |
| | 4.2.3a | **The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated** | | | X | | | | Distribution appears to be unregulated | | |
| | 4.2.3b | **The EPP shall be tested.** | | | X | | | | No documentation of annual testing but the EPP received the equivalent of a test during the 2006 dyke breach at Snare Forks. | | |
| | 4.2.3c | **For dams under construction, the EPP shall be reviewed annually and updated as appropriate** | N/A | | | | | | Not applicable (dam already built) | | |
| **4.2.4** | **Training** | | | | | | | | | | |
| | 4.2.4a | **Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties** | | | | X | | | No documentation of Operator training | | |
| **4.3** | **INUNDATION STUDIES** | | | | | | | | | | |
| | 4.3a | **A dam breach inundation study shall be carried out for all dams that clearly require EPPs (see Section 4.1) and for dams where it is not obvious whether or not an EPP is needed** | X | | | | | 2000 DSR | | | |
| | 4.3b | **The inundation study shall be based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions** | X | | | | | 2000 DSR | | | |
| **5.0** | **EARTHQUAKES** | | | | | | | | | | |
| | 5.0a | **Dams shall be designed and evaluated to withstand ground motions associated with a Maximum Design Earthquake (MDE), without release of the reservoir.** | X | | | | | This report | | | |
| | 5.0b | **Selection of the MDE for a dam shall be based on the consequences of dam failure** | X | | | | | This report | | | |
| **6.0** | **FLOODS** | | | | | | | | | | |
| **6.1** | **GENERAL** | | | | | | | | | | |
| | 6.1a | **Dams shall be designed and evaluated to safely pass an Inflow Design Flood (IDF). Selection of the IDF for a dam shall be based on the consequences of failure.** | X | | | | | 2000 DSR (re-confirmed this report) | | | |
| | 6.1b | **For new dams with very high or high consequences of failure, the maximum design floods at the dam site shall be evaluated by both statistical analysis and deterministic methods** | N/A | | | | | | Not applicable (not a new dam) | | |
| **6.2** | **STATISTICAL FLOOD ANALYSIS** | | | | | | | | | | |
| | 6.2a | **If the IDF is statistically determined, the reliability of existing statistical flood analysis shall be confirmed or a new statistical flood analysis shall be developed** | X | | | | | This report | | | |
| | 6.2b | **If an unusual event has been recorded since the statistical flood was evaluated, or if the duration of the available hydrological data has increased by more than 50%, a new statistical flood analysis shall be carried out.** | X | | | | | This report | No new hydrological events occurred since previous evaluation; data since 2000 reviewed for this report. | | |
| **6.3** | **PROBABLE MAXIMUM FLOOD (PMF)** | | | | | | | | | | |
| | 6.3a | **A Probable Maximum Flood (PMF) study shall consider the most severe "reasonably possible" combination of the following phenomena on the watershed upstream of the structure under study:** | N/A | | | | | | | | |
| | 6.3a.1 | **- Rainstorm;** | N/A | | | | | | | | |
| | 6.3a.2 | **- Snow accumulation;** | N/A | | | | | | | | |
| | 6.3a.3 | **- Melt rate;** | N/A | | | | | | | | |
| | 6.3a.4 | **- Initial basin conditions (e.g. soil moisture, lake and river levels);** | N/A | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6.3a.5 | **- Prestorm.** | **N/A** | | | | | | | | |
| | 6.3b | **When the PMF is identified as the IDF for a particular project, the acceptability of any previous PMF analysis must be confirmed or a new PMF analysis undertaken.** | **N/A** | | | | | | | | |
| **7.0** | **DISCHARGE FACILITIES** | | | | | | | | | | |
| **7.1** | **FLOW CAPACITY OF HYDRAULIC STRUCTURES** | | | | | | | | | | |
| | 7.1a | **The discharge facilities shall be designed or modified to be capable of passing the IDF, taking into account the routing effect of the reservoir, without the reservoir level infringing on the freeboard established in Section 7.2 for this condition.** | **X** | | | | | 2000 DSR | | | |
| | 7.1b | **New dams shall be designed such that:** | **N/A** | | | | | | Not applicable (not a new dam) | | |
| | 7.1b.1 | **- The outflow structure handles ice and debris:** | **N/A** | | | | | | Ditto | | |
| | 7.1b.2 | **- Water conveyance structures resist the anticipated high velocities** | **N/A** | | | | | | Ditto | | |
| | 7.1b.3 | **- Energy dissipation structures protect the dam during the passages of the IDF** | **N/A** | | | | | | Ditto | | |
| **7.2** | **FREEBOARD** | | | | | | | | | | |
| | 7.2a | **Sufficient freeboard shall be provided so that under all operating conditions, including those during extreme floods or extreme wind conditions the percentage of waves that could overtop the dam is limited to an amount that would not lead to dam failure.** | **X** | | | | | 2000 DSR | | | |
| | 7.2b | **The maximum reservoir level shall be at or below the top of the impervious core for embankment dams** | **X** | | | | | 2000 DSR | | | |
| **7.3** | **OPERATION DURING FLOODS** | | | | | | | | | | |
| | 7.3a | **All discharge facilities shall be operated at all times according to a set of pre-determined rules. The development of such rules shall consider the safe passage of all hydrological events, including the IDI** | **X** | | | | | Snare OMS manual includes operating rules. | | | |
| | 7.3b | **For new dams, rule curves shall be established for operation during the flood season, such that all floods, including the IDF, can be passed safely.** | **N/A** | | | | | | Not applicable (not a new dam) | | |
| **7.4** | **OPERATION OF FLOW CONTROL EQUIPMENT** | | | | | | | | | | |
| | 7.4a | **The conditions under which the spillway, discharge facilities and power intake must operate, as well as the level of automation associated with the equipment, shall be determined on a site-specific basis.** | **X** | | | | | | Spillway is capable of local and remote operation. Gates are monitored both locally and from remote operations centre. | | |
| | 7.4b | **All flow control equipment shall be designed to be capable of opening and closing under required operating conditions. The required service shall be determined by a site-specific evaluation of requirements.** | **X** | | | | | | Intake gates tested annually for emergency close and are capable of closing without power. Spillway gates have two backup power supplies. 1 gate is suitable for winter operation and the second gate is being upgraded for winter operation. | | |
| **7.5** | **INSTRUMENTATION AND CONTROL** | | | | | | | | | | |
| | 7.5a | **Equipment on Very High and High Consequence structures shall be provided with instrumentation to enable local and/o remote monitoring of conditions at the hydraulic structures.** | **X** | | | | | | Spillway is capable of local and remote operation. Gates are monitored both locally and from remote operations centre. | | |
| **7.6** | **EMERGENCY EQUIPMENT** | | | | | | | | | | |
| | 7.6a | **As a minimum, emergency power equipment shall be available for installation in a reasonable amount of time at Very High and High Consequence structures. Otherwise, permanent emergency power equipment shall be installed.** | **X** | | | | | | Backup power is available for the spillway and intake gates. A secondary overflow weir spillway is located beside the spillway gate structure. | | |
| | 7.6b | **Controls and instrumentation shall permit operation and monitoring during power outage conditions for Very High and High Consequence structures** | **X** | | | | | | Spillway gates have two backup power supplies | | |
| **8.0** | **GEOTECHNICAL CONSIDERATIONS** | | | | | | | | | | |
| **8.1** | **GEOTECHNICAL INVESTIGATIONS FOR NEW DAMS** | | | | | | | | | | |
| | 8.1a | **Adequate geotechnical investigations shall be carried out on the site selected for a new dam** | **N/A** | | | | | | Not applicable (not a new dam) | | |
| | 8.1b | **A permanent record or log shall be kept of all inspections, investigation reports, drawings and design reports.** | | | | **X** | | | No log of dam safety or records of inspections were available. | | |
| **8.2** | **EMBANKMENT DAMS AND SOIL FOUNDATIONS** | | | | | | | | | | |
| **8.2.1** | **Monitoring and Instrumentation** | | | | | | | | | | |
| | 8.2.1a | **Sufficient instrumentation for the embankment dam and foundation shall be provided, commensurate with the Consequence Category, so that the performance can be adequately monitored and dam safety can be evaluated.** | **X** | | | | | | | | |
| | 8.2.1b | **For new dams, sufficient instrumentation shall be provided to adequately monitor the dam and evaluate its performance.** | **N/A** | | | | | | Not applicable (not a new dam) | | |
| **8.2.2** | **Stability and Deformation** | | | | | | | | | | |
| | 8.2.2a | **The slopes of the dam and the abutment shall be designed so that the dam, foundation and abutments are stable under all stages of construction, reservoir levels and operating conditions.** | | **X** | | | | | Saddle Dam 1 and 2, are low structures designed with conservative slopes. No stability issues identified | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.2.2b | **The slopes of the dam and the abutment shall be designed not to cause unacceptable deformation in the dam or foundation.** | X | | | | | | | | |
| | 8.2.2c | **The stability of reservoir slopes shall be evaluated under seismic loads, heavy rainfall, rapid drawdown and any other conditions, if slope failure could induce waves that pose an unacceptable risk to public safety, the dam or its appurtenant structures.** | X | | | | | | | | |
| | 8.2.2d | **If necessary, such slopes shall be stabilized or the public otherwise protected from the effects of slope failure.** | N/A | | | | | | | | |
| | 8.2.2e | **Any material stockpiled upstream of a tailings dam shall be maintained in a stable configuration, if it can affect the stability of the dam or its appurtenant structures either directly or by destabilising stored or stockpiled tailings.** | N.A | | | | | | | | |
| | 8.2.2f | **Sufficient freeboard shall be provided to accommodate expected settlement of the crest and cracks caused by frost action.** | X | | | | | 2000 DSR | | | |
| **8.2.3** | **Seepage and Drainage Control** | | | | | | | | | | |
| | 8.2.3a | **Filters shall be placed between materials where otherwise significant migration of particles by seepage forces would be possible.** | | X | | | | | Sand filters provided between core and shell material of main dam. | | |
| | 8.2.3b | **Construction of embankments, structural cutoffs and foundation treatment shall be staged such that adequate filters are in place.** | | X | | | | | | | |
| | 8.2.3c | **Filter provisions shall be adequate to accommodate the movements and avoid erosion induced by the design earthquake.** | | X | | | | | Dam stable under low seismic loading | | |
| | 8.2.3d | **The hydraulic gradients in the dam, in foundation abutments and along conduits, shall be low enough to prevent piping and heave in the existing material** | | X | | | | | | | |
| | 8.2.3e | **The flow capacity of filters and drains shall be designed to accommodate the maximum anticipated seepage.** | | X | | | | | Shells of the dam are rockfill and likely free draining. | | |
| **8.2.4** | **Cracking** | | | | | | | | | | |
| | 8.2.4a | **The dam shall be designed to retain the reservoir safely in spite of any cracking that may be induced by settlement or hydraulic fracturing.** | | X | | | | | There is no evidence that excessive settlement or hydraulic fracturing has occurred. Cracks have not been identified in the past. | | |
| **8.2.5** | **Surface Erosion** | | | | | | | | | | |
| | 8.2.5a | **The upstream slopes of the dam and its abutments shall be provided with adequate protection to guard against erosion and possible breaching due to wave and ice action and against burrowing animals such as beaver and muskrat. Failure of riprap must not result in dam failure.** | X | | | | | | | | |
| | 8.2.5b | **The downstream slopes shall be protected where necessary against the erosive action of runoff, seepage flows, traffic, frost and burrowing animals.** | X | | | | | | | | |
| | 8.2.5c | **Inlet and outlet channels for spillways and conduits shall be adequately protected against erosion.** | X | | | | | | | | |
| | 8.2.5d | **Temporary and permanent slopes of the embankments and abutments shall be adequately protected against wave action, runoff and seepage flows during construction** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.2.6** | **Liquefaction** | | | | | | | | | | |
| | 8.2.6a | **All embankment and foundation materials susceptible to liquefaction shall be identified.** | N/A | | | | | | Not assessed but consierd not applicable | | |
| | 8.2.6b | **If liquefaction is possible under static conditions or probable under design earthquake loading, the post-liquefaction stability of the dam shall be evaluated.** | N/A | | | | | | | | |
| | 8.2.6c | **If unacceptable flowsliding is probable following liquefaction, appropriate remedial measures shall be undertaken to ensure dam failure does not occur.** | N/A | | | | | | | | |
| **8.2.7** | **Earthquake Resistance** | | | | | | | | | | |
| | 8.2.7a | **The dam, appurtenant structures, foundation and abutments shall be designed to resist the forces associated with the Maximum Design Earthquake (MDE).** | | | | X | | | Stability of intake and spillway structures not evaluated | | |
| | 8.2.7b | **Embankments and foundations that are required to impound temporary reservoirs during construction shall be designed to resist forces associated with the MDE selected for their design** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.3** | **DAMS ON ROCK FOUNDATIONS** | | | | | | | | | | |
| **8.3.1** | **Foundation Stability** | | | | | | | | | | |
| | 8.3.1a | **For new dams rock foundations shall be excavated to a depth, and grouted, such that they have sufficient strength, watertightness and stiffness:** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 8.3.1a.1 | **- to support all stages of construction and initial reservoir filling and drawdown** | N/A | | | | | | | | |
| | 8.3.1a.2 | **- to provide adequate stability under design loads for the dam, appurtenances, abutments and foundation** | N/A | | | | | | | | |
| | 8.3.1a.3 | **- to limit deformations to acceptable values.** | N/A | | | | | | | | |
| **8.3.2** | **Shear Strength Parameters** | | | | | | | | | | |
| | 8.3.2a | **The dam shall be designed such that the shear strength of the rock foundations is adequate at all stages of construction, initial reservoir filling and drawdown, to ensure the stability of a dam at and within its foundation.** | | X | | | | 2000 DSR | | | |
| **8.3.3** | **Seepage and Drainage** | | | | | | | | | | |

## Table 14-3: 2006 Dam Safety Review
## Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** procedural, operational or maintenance aspect.

**DEFICIENCY =** aspect or condition that could (potentially or actually) threaten safety

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | Reference | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.3.3a | If the rock is not of sufficient quality, adequate protection shall be provided to protect against internal erosion, leaching, or solution effects in foundations or abutments. | | X | | | | | Satisfactory operating history (40 years) of dam indicates that foundation is adequate. | | |
| | 8.3.3b | The foundation and abutment grouting and drainage systems shall maintain foundation water pressures at acceptable levels. | N/A | | | | | | No grouting or drainage of bedrock are shown on drawings. | | |
| | 8.3.3c | Where embankments are constructed on rock foundations, the treatment of the foundation shall be compatible with the embankment materials, such that migration of the embankment material is prevented. | | X | | | | | No foundation treatment shown on drawings. Satisfactory performance indicates adequate treatment. | | |
| | 8.3.3d | Provision shall be made to control unacceptable quality and quantity of seepage for all stages of construction, initial reservoir filling, operation and drawdown. | | X | | | | | Satisfactory performance indicates adequate control. | | |
| 8.4 | DAMS ON PERMAFROST | | | | | | | | | | |
| | 8.4a | Dams on permafrost shall meet the same stability requirements as other embankment dams, and shall remain stable in spite of large foundation settlements. | | | | | | | Saddle Dam No. 1 and 2 have satisfactory performance history despite settlement. | | |
| | 8.4b | The freeboard shall be adequate to accommodate the expected settlement. | | | | | | | Saddle Dam No.1 excavated down to act as fuseplug spillway. Saddle Dam No.2 adeqaute | | |
| | 8.4c | The fill zones shall have sufficient integrity to prevent piping and limit seepage to an acceptable amount. | | | | | | | Homogeneous Saddle Dam No. 2 has no observable seepage. | | |
| 8.5 | APPURTENANT STRUCTURES | | | | | | | | | | |
| 8.5.1 | Foundation Movement | | | | | | | | | | |
| | 8.5.1a | *In situ* foundations and abutments as well as embankments and backfill, through which or on which an appurtenant hydraulic structure will be constructed, should be designed to be free from gravity-driven movements that would impair the operational capability of the structure or lead to structural damage such as excessive cracking, deformation, deflection, damage to joints, threaten the structural integrity and hydraulic performance. Likewise, the foundations and embankment shall be protected from any potential adverse effects of any leakage from any conduit or structures. | | X | | | | | No record of movements of appurtenant structures or abutments. | | |
| | 8.5.1b | The foundation of an appurtenant hydraulic structure, whether *in situ* or compacted earthen materials, shall be designed to avoid differential settlement or heave that would either damage seals, waterstops or joints, or misalign or crack slabs or monoliths | | X | | | | | Intake structure and spillway constructed on bedrock. | | |
| 8.5.2 | Slope Stability | | | | | | | | | | |
| | 8.5.2a | Slopes flanking the approach and exit channels of an appurtenant hydraulic structure shall be designed to be stable to the extent that any instability under the broad category of gravity-driven soil and rock movement does not restrict these channels. | X | | | | | | Rock slopes d/s of spillway. | | |
| 8.5.3 | Seepage | | | | | | | | | | |
| | 8.5.3a | The impervious or seepage-control zone immediately underlying or enclosing the upstream portion of an appurtenant hydraulic structure, including components such as cut-off, core trench or upstream blanket shall be designed to be free of localised concentrations of seepage that could lead to piping. In the case of new dams, this impervious or seepage-control zone shall be free of deleterious hydraulic and material conditions which individually or in combination could lead to excessive seepage and piping. | | X | | | | | Performance record indicates adequate seepage control at control structures. | | |
| 8.6 | GABION, ROCK CRIB AND TIMBER STRUCTURES | | | | | | | | | | |
| | 8.6a | Gabion, rock crib and timber dams, and their foundations, shall meet the same stability requirements as all dams. In addition, the timber shall maintain durability and be capable of transmitting the induced loads | N/A | | | | | | No timber crib features | | |
| 8.7 | MEMBRANE-FACED ROCKFILL DAMS | | | | | | | | | | |
| | 8.7a | Membrane-faced rockfill dams and their foundations shall meet the same stability requirements as other embankment dams. The integrity of the upstream membrane shall be designed to minimize the effects of settlement, ultraviolet deterioration and any other damage that would permit excessive leakage. | N/A | | | | | | Not a membrane faced rockfill dam. | | |
| | 8.7b | Seepage or leakage through the membrane face shall be limited to values that will not adversely affect dam stability. | N/A | | | | | | | | |
| 8.8 | FLOW-THROUGH ROCKFILL DAMS | | | | | | | | | | |
| | 8.8a | For the design flood, flow-through rockfill dams shall be designed to withstand the combined effects of the action of the seepage emerging from the downstream face, along with any overflow without local or massive movement of rock particles. | N/A | | | | | | Not a flow-through rockfill dam. | | |
| 9.0 | CONCRETE STRUCTURES | | | | | | | | | | |
| 9.1 | GENERAL | | | | | | | | | | |
| | 9.1a | The level of design or safety assessment for concrete dams and other water-retaining structures shall take into account the consequences of failure of the structure. | | | | X | | 2000 DSR, this report | Spillway stability not assessed, Intake stability not assessed | Insufficient data available to KCBL | Spillway stability assessment required, Intake stability assessment required |
| 9.2 | CONDITION OF STRUCTURES AND SITES | | | | | | | | | | |
| | 9.2a | The strength and condition of the dam and foundation shall be determined to the extent required for the design of a new dam or analysis of an existing dam. | | | | X | | | See 9.1a | | |
| | 9.2b | If the concrete appears to be damaged or weakened, tests shall be carried out to determine its strength parameters, or suitably conservative assumptions made in the analysis of its safety | X | | | | | 2000 DSR, this report | Concrete structures inspected and determined to be adequate. | | |

## Table 14-3: 2006 Dam Safety Review
## Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** **procedural, operational or maintenance aspect.**

**DEFICIENCY =** **aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.2c | **For High and Very High Consequence dams, sufficient instrumentation shall be provided for the structure and foundation, to allow performance to be monitored and safety to be evaluated.** | X | | | | | | Instrumentation of the spillway and intake structures is not considered necessary | | |
| **9.3** | **LOADS** | | | | | | | | | | |
| | 9.3a | **The following loads shall be considered in the design or assessment of concrete structures** | | | | X | | | See 9.1a | | |
| | 9.3a.1 | **- Dead loads of permanent structures and equipment (D);** | | | | X | | | See 9.1a | | |
| | 9.3a.2 | **- Maximum normal headwater level (H) combined ,with the most critical concurrent tailwater level** | | | | X | | | See 9.1a | | |
| | 9.3a.3 | **- Maximum flood headwater level ($H_F$) based on the Inflow Design Flood (IDF) with corresponding tailwater levels;** | | | | X | | | See 9.1a | | |
| | 9.3a.4 | **- Internal water pressure and foundation uplift (U);** | | | | X | | | See 9.1a | | |
| | 9.3a.5 | **- Static and dynamic thrust created by an ice sheet, for reservoirs subject to freezing (I)** | | | | X | | | See 9.1a | | |
| | 9.3a.6 | **- Vertical and horizontal loading due to rock or soil backfill, including potential effects of liquefaction, as well as loads from silt deposited against the structure (S);** | | | | X | | | See 9.1a | | |
| | 9.3a.7 | **- Maximum Design Earthquake (Q);** | | | | X | | | See 9.1a | | |
| | 9.3a.8 | **- Temperature-induced loads (T), for stability and stress analysis of concrete structures with grouted contraction joints, especially buttress and arch dams.** | N/A | | | | | | | | |
| **9.4** | **LOAD COMBINATIONS** | | | | | | | | | | |
| **9.4.1** | **Usual Loading** | | | | | | | | | | |
| | 9.4.1a | **Permanent and operating loads shall be considered for both summer and winter conditions including self-weight, ice, silt, earth pressure, and the normal maximum operating water level with appropriate uplift pressures and tailwater level (D+H+I+S+U).** | | | | X | | | See 9.1a | | |
| **9.4.2** | **Unusual Loading** | | | | | | | | | | |
| | 9.4.2a | **Where earthquake-induced cracking at the rock concrete interface or any weak section is identified, a stability analysis shall be carried out to see whether the structure in its post-earthquake condition is still capable of resisting the Usual Loading ($D+H+S+U_{PQ}$).** | | | | X | | | See 9.1a | | |
| **9.4.3** | **Flood Loading** | | | | | | | | | | |
| | 9.4.3a | **Permanent and operating loads of the Usual Loading, except for ice loading, shall be considered in conjunction with reservoir and tailwater levels and uplift resulting from the passage of the Inflow Design Flood (IDF) ($D+H+S+U_F$).** | | | | X | | | See 9.1a | | |
| **9.4.4** | **Earthquake Loading** | | | | | | | | | | |
| | 9.4.4a | **Permanent and operating loads of the Usual Loading case shall be considered in conjunction with the seismic loads of the Maximum Design Earthquake (MDE) ($D+H+S+Q+U_Q$).** | | | | X | | | See 9.1a | | |
| **9.4.5** | **Temperature Loading** | | | | | | | | | | |
| | 9.4.5a | **Permanent and operating loads from the Usual Loading case shall be considered in conjunction with temperature loads for buttress and arch dams (D+H+I+S+U+T).** | N/A | | | | | | | | |
| **9.5** | **DESIGN AND ANALYSIS** | | | | | | | | | | |
| | 9.5a | **Concrete dams shall be designed to resist and prevent** | | | | X | | | See 9.1a | | |
| | 9.5a.1 | **- Sliding at the dam-foundation interface, within the dam and at any plane in the foundation** | | | | X | | | See 9.1a | | |
| | 9.5a.2 | **- Overturning;** | | | | X | | | See 9.1a | | |
| | 9.5a.3 | **- Overstressing of the concrete dam or foundation;** | | | | X | | | See 9.1a | | |
| | 9.5a.4 | **- Excessive seepage through the foundation or through joints in the concrete dam** | | | | X | | | See 9.1a | | |
| | 9.5b | **Safety analyses for existing concrete dams shall take into account their ability to resist and prevent the above conditions.** | | | | X | | | See 9.1a | | |
| | 9.5c | **Stresses and stability of a concrete gravity dam shall be evaluated for ground motions in the upstream-downstream direction. If the geometry suggests potential "pounding" of adjacent blocks, cross-valley analyses shall be undertaken.** | | | | X | | | See 9.1a | | |
| | 9.5d | **Stresses and stability of a buttress dam shall be evaluated for ground motions in the upstream-downstream as well as the cross-valley directions** | N/A | | | | | | | | |
| **9.6** | **PERFORMANCE INDICATORS** | | | | | | | | | | |
| | 9.6a | **The design and assessment of concrete dams and other water-retaining structures shall be based on performance indicators such as:** | | | | X | | | See 9.1a | | |
| | 9.6a.1 | **- Position of resultant force;** | | | | X | | | See 9.1a | | |
| | 9.6a.2 | **- Normal stresses at the heel and the toe;** | | | | X | | | See 9.1a | | |
| | 9.6a.3 | **- Average shear stresses acting on the surface** | | | | X | | | See 9.1a | | |
| | 9.6a.4 | **- Calculated sliding factors and strength factors;** | | | | X | | | See 9.1a | | |
| | 9.6a.5 | **- Observed conditions of structure and site** | X | | | | | 2000 DSR, this report | | | |
| **9.7** | **ACCEPTANCE CRITERIA** | | | | | | | | | | |
| | 9.7a | **Concrete gravity, buttress and arch dams and their foundations shall have adequate sliding resistance to withstand all reasonable loads and load combinations that could occur** | | | | X | | | See 9.1a | | |
| | 9.7b | **The concrete must have sufficient strength that the loads will not result in excessive deformations or overstressing.** | | | | X | | | See 9.1a | | |

## Table 14-3: 2006 Dam Safety Review
## Conformance of Snare Falls with CDA Dam Safety Guidelines

**NON-CONFORMANCE =** procedural, operational or maintenance aspect.

**DEFICIENCY =** aspect or condition that could (potentially or actually) threaten safety

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | Reference | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.7c | **During and after extreme events such as the IDF and the MDE, the dam shall continue to safely retain the reservoir water.** | | | | X | | | See 9.1a | | |
| | 9.7d | **The level of safety of appurtenant structures shall be compatible with the consequences of their failure.** | N/A | | | | | | No concrete appurtenance structures governed by DSR requirements | | |
| | 9.7e | **The effects of static and dynamic (seismic) loadings on support structures for mechanical and electrical equipment that relate to dam safety shall be examined to ensure that structural integrity and functionality are preserved.** | | X | | | | | Not assessed but MDE is low | | |
| **9.8** | **ROLLER-COMPACTED CONCRETE (RCC) DAMS** | | | | | | | | | | |
| | 9.8a | **Roller-compacted concrete (RCC) dams shall meet the same stability and performance specifications as conventional concrete gravity dams.** | N/A | | | | | | | | |
| **10.0** | **RESERVOIR AND ENVIRONMENT** | | | | | | | | | | |
| **10.1** | **RESERVOIR DEBRIS AND ICE** | | | | | | | | | | |
| | 10.1a | **Reservoir debris and ice shall be managed in such a way that they do not constitute an unacceptable risk to dam safety.** | X | | | | | | One spillway gate heated for winter operation. Second gate could be de-iced and operated in emergency. | | **Recommend convert second gate to full operating capability in winter.** |
| **10.2** | **RESERVOIR RIM** | | | | | | | | | | |
| | 10.2a | **Unstable slopes or slopes which are potentially unstable under extreme loading, or rapid reservoir drawdown condition around the reservoir rim shall be monitored and treated if necessary so that they do not constitute an unacceptable risk to the safety of the dam.** | N/A | | | | | | | | |
| | 10.2b | **Any point on the rim of the reservoir which forms a natural barrier shall be treated in the same manner as a dam, if its failure could release the reservoir.** | N/A | | | | | | | | |
| | 10.2c | **Excessive seepage through the reservoir rim shall be controlled so that it does not constitute an unacceptable risk to the safety of the dam or reservoir.** | N/A | | | | | | | | |
| **10.3** | **WATER QUALITY** | | | | | | | | | | |
| | 10.3a | **Consideration shall be given to monitoring detrimental effects on structural elements of the dam from chemical interaction between groundwater, reservoir water, natural soil, and all dam materials, and to taking necessary protective measures.** | X | | | | | | No report of water quality issue in many years of operation. | | |
| **10.4** | **SEDIMENTATION AND SILTING** | | | | | | | | | | |
| | 10.4a | **Silt deposition near the dam and discharge facilities shall be monitored as appropriate and if the continued deposition could impair the safe routing of floods or the stability of the dam, appropriate remedial measures shall be taken.** | X | | | | | | No evidence of siltation at any structure. | | |
| | 10.4b | **Tailings shall not be deposited in such a manner as to hinder the operation or stability of a dam and its appurtenant structures.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **10.5** | **RESERVOIR DRAWDOWN CAPABILITY** | | | | | | | | | | |
| | 10.5a | **At dams that are subject to severe damage by earthquake or landslides, or where a high potential for internal erosion exists, outlet facilities shall be provided to quickly lower the reservoir to a safe level for the dam in its damaged state.** | X | | | | | | Saddle Dam No.1 has been lowered in order to function as a fuseplug spillway in the event that emergency discharges are required | | |
| **10.6** | **ECOLOGY** | | | | | | | | | | |
| | 10.6a | **The dam shall be monitored for dam safety hazards presented by animals, birds, vegetation or other organisms, and protective action taken if required.** | | X | | | | | Maintenance required locally to remove vegetation. | | |
| **10.7** | **REHANDLING OF TAILINGS** | | | | | | | | | | |
| | 10.7a | **The rehandling of tailings or other materials upstream of, or adjacent to a dam, shall be undertaken in such a manner that the safety or safe operation of a dam and appurtenances is not impaired.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **11.0** | **CONSTRUCTION** | | | | | | | | | | |
| | 11a | **An Engineer shall ensure that the project specifications are strictly adhered to. Any deviation from the prescribed specifications are allowed only if approved by the design engineer** | N/A | | | | | | | | |
| | 11b | **The Engineer shall document and approve all phases of the project construction** | N/A | | | | | | | | |
| | 11c | **Temporary construction facilities shall be constructed such that there is no adverse impact on the safety of the dam or appurtenant structures.** | N/A | | | | | | | | |

# Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | . | | | | | | | | | | |
| **1.0** | **SCOPE, DEFINITIONS AND GENERAL REQUIREMENTS** | | | | | | | | | | |
| **1.1** | **SCOPE AND APPLICABILITY OF THE GUIDELINES** | | | | | | | | | | |
| **1.2** | **DEFINITIONS** | | | | | | | | | | |
| **1.3** | **RESPONSIBILITY FOR DAM SAFETY** | | | | | | | | | | |
| **1.3.1** | **General** | | | | | | | | | | |
| | **1.3.1a** | **The responsibility for all aspects of the safety of a dam shall be clearly defined and delegation of responsibility and authority shall be documented.** | | | X | | | Snare OMS and EPP manuals | Updating and reorganization of the manuals is required. | | |
| **1.4** | **CLASSIFICATION OF DAMS** | | | | | | | | | | |
| | **1.4a** | **Each dam, water control structure or water passage, shall be classified in terms of the reasonably foreseeable incremental consequences of failure.** | X | | | | | This review | | | |
| | **1.4b** | **The loss of life consequences shall be evaluated separately from the socioeconomic, financial and environmental consequences and the higher of the two classifications shall be used** | X | | | | | This review | | | |
| | **1.4c** | **For new dams, the consequences category shall be established during feasibility studies used for design, and confirmed prior to first reservoir filling.** | N/A | | | | | | Not a new dam | | |
| **1.5** | **SELECTION OF SAFETY CRITERIA** | | | | | | | | | | |
| | **1.5a** | **The dam, along with its foundation and abutments, shall be designed to have adequate stability to safely withstand extreme loads as well as the normal design loads.** | X | | | | | | | | |
| | **1.5b** | **The selection of loading criteria for extreme loads shall be based on the consequences of failure of the dam.** | X | | | | | | | | |
| | **1.5c** | **For tailings dams, the loading criteria or level of safety at any stage of construction shall be commensurate with the consequences of failure at that stage , with due consideration of the consequences at future stages** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **1.6** | **DECOMMISSIONING AND CLOSURE** | | | | | | | | | | |
| | **1.6a** | **A dam shall be decommissioned and considered closed only when all the requirements of a decommissioning plan have been complied with.** | N/A | | | | | | | | |
| | **1.6b** | **Demolition of a dam or removal of any of its appurtenances shall be based on sound practice and carried out without increasing the risk of failure of remaining structures and appurtenances or causing adverse impacts downstream of the dam.** | N/A | | | | | | | | |
| | **1.6c** | **Demolition operations shall not result in blockage or reduction of the safe discharge of natural floods. That part of the dam and its appurtenant structures which may obstruct the discharge of the water course or drainage course such that it causes upstream flooding beyond that of the existing dam and appurtenent structures or leads to a sudden release of water, must be completely removed.** | N/A | | | | | | | | |
| | **1.6d** | **Structures that remain after decommissioning shall be physically and chemically stable, and shall not impose an unacceptable risk to public health and safety, or the environment.** | N/A | | | | | | | | |
| | **1.6e** | **Closure requirements for tailings dams must be considered and incorporated into the initial design stage and at all subsequent design and construction phases.** | N/A | | | | | | | | |
| | **1.6f** | **Any tailings dam that retains contaminated or acid generating materials shall be monitored and maintained, to a level commensurate with the consequences of failure, after infilling is completed or mining operations are terminated.** | N/A | | | | | | | | |
| | . | | | | | | | | | | |
| **2** | **DAM SAFETY REVIEW** | | | | | | | | | | |
| **2.1** | **GENERAL** | | | | | | | | | | |
| | **2.1a** | **A Dam Safety Review (the "Review") shall be carried out by a qualified engineer (the "Engineer") at regular time intervals for dams and associated facilities. The review shall include the design, operation, maintenance, surveillance and emergency plans, to determine if they are safe in all respects and, if they are not, to determine required safety improvements.** | X | | | | | | | | |
| | **2.1b** | **The first Dam Safety Review for a new dam shall be completed within three years of initial filling** | N/A | | | | | | Not the first dam safety review | | |
| | **2.1c** | **A Dam Safety Review shall be carried out when there are significant changes in the stage of construction of a tailings dam, or the condition of any dam, including:** | N/A | | | | | | See individual comments below | | |
| | **2.1c.1** | **- Major modification to the original design or design criteria;** | N/A | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

## Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.1c.2 | **- Discovery of an unusual condition;** | **N/A** | | | | | | Not applicable (no unusual condition prior to DSR) | | |
| | 2.1c.3 | **- Decommissioning;** | **N/A** | | | | | | Not applicable (facility still in full operation). | | |
| | 2.1c.4 | **- After an extreme hydrological or seismic event.** | **N/A** | | | | | | Not applicable (no extreme hydrological or seismic events). | | |
| **2.2** | **DETAILS OF REVIEW** | | | | | | | | | | |
| **2.2.1** | **Dam Classification** | | | | | | | | | | |
| | 2.2.1a | **The Review shall include the classification of the dam, as outlined in Section 1.4** | **X** | | | | | | | | |
| **2.2.2** | **Site Inspection** | | | | | | | | | | |
| | 2.2.2a | **The Review shall include an appropriately comprehensive field inspection of the dam and appurtenant structures, and documentation thereof.** | | | | **X** | | | Twin box culvert not inspected. | | Inspect and document box culvert condition, esp. crack, when accessible |
| **2.2.3** | **Design and Construction** | | | | | | | | | | |
| | 2.2.3a | **The Review of design and construction shall be sufficiently comprehensive to demonstrate whether the dam, discharg facilities and reservoir slopes meet all currently applicable safety requirements** | **X** | | | | | | | | |
| **2.2.4** | **Operation and Testing** | | | | | | | | | | |
| | 2.2.4a | **The Review shall determine if safe operating procedures have been developed, documented and followed in all respects. The adequacy of the documentation shall be reviewed** | **X** | | | | | Snare Hydro OMS manual | | | |
| | 2.2.4b | **The Review shall include the testing of equipment required to operate discharge facilities (including backup equipment and emergency power supply) that are required for the safe passage of the inflow design flood, and any other flood tha could endanger the dam, and adequacy of ice and debris control facilities and procedures to verify that they will function as and when required.** | | | | **X** | | | No records provided of intake gate testing. | | |
| **2.2.5** | **Maintenance** | | | | | | | | | | |
| | 2.2.5a | **The Review shall ascertain if all facilities required for safety of the dam, including dam monitoring instrumentation, are maintained in satisfactory condition in accordance with a manual defining the maintenance requirements for dam safety.** | | | | **X** | | | No inspection or maintenance records provided. | | |
| **2.2.6** | **Surveillance and Monitoring of Dam Performance** | | | | | | | | | | |
| | 2.2.6a | **The Review shall determine if the surveillance and monitoring methods and frequency are adequate to detect any unsafe condition in a timely manner.** | **X** | | | | | | | | |
| | 2.2.6b | **The Review shall determine if monitoring data have been regularly analysed and used to ensure prompt detection of any potentially unsafe conditions in the dam, associated water containment and reservoir slopes.** | | | | **X** | | | No documentation available showing analysis of dam safety monitoring measurements or test results of operating equipment | | |
| **2.2.7** | **Emergency Preparedness** | | | | | | | | | | |
| | 2.2.7a | **The Review shall determine if the appropriate level of emergency preparedness exists and is adequately documented. The adequacy of warning systems, training and emergency response plans shall be reviewed, as well as testing and updating of plans.** | | | **X** | | | Snare Hydro EPP manual | Updating required. See report for specifics. | | |
| **2.2.8** | **Compliance with Previous Reviews** | | | | | | | | | | |
| | 2.2.8a | **Previous Dam Safety Reports shall be reviewed to determine compliance with their recommendations.** | | | **X** | | | 2000 DSR | | Erosion, right side of spillway, identified in 2000, not adequately addressed. | |
| **2.3** | **DAM SAFETY REPORT** | | | | | | | | | | |
| | 2.3a | **A Dam Safety Report ("the Report"), covering all aspects of the dam's safety, shall be prepared, documenting the Dam Safety Review.** | **X** | | | | | This report | | | |
| | 2.3b | **The Report shall identify any additional steps required for the safe operation, maintenance and adequate surveillance of the dam.** | **X** | | | | | This report | | | |
| **2.4** | **FAILURE TO MEET REQUIREMENTS** | | | | | | | | | | |
| | 2.4a | **If the dam and/or appurtenant structures fails to meet the safety requirements, safety improvements shall be carried out as appropriate, including:** | **N/A** | | | | | | | | |
| | 2.4a.1 | **- Safety improvements of the physical facilities** | | | **X** | | | | See Table 14.1 | | |
| | 2.4a.2 | **- Nonstructural improvements;** | **X** | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

# Table 14-4:  2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE =  procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.4a.3 | **- Overcoming any deficiencies in operation, surveillance, inspection or maintenance of the dam, or emergency preparedness.** | | | X | | | | See Table 14.1 | | |
| | . | | | | | | | | | | |
| **3.0** | **OPERATION, MAINTENANCE AND SURVEILLANCE** | | | | | | | | | | |
| **3.1** | **GENERAL** | | | | | | | | | | |
| | 3.1a | **Dam operation, maintenance and surveillance shall be provided so that an acceptable level of dam safety is ensured.** | X | | | | | | | | |
| | 3.1b | **A manual (the "OMS Manual") shall be prepared, documenting operation, maintenance and surveillance for each applicable dam. The OMS manual shall be implemented, followed, and updated at appropriate intervals. The manual shall contain suitable and sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition, and monitor its performance well enough to provide early signs of any distress.** | | | X | | | Snare OMS Manual | Updating required. Refer to report for specifics. | | |
| | 3.1c | **For tailings dams a separate OMS Manual shall be prepared for the closure stage or included in the decommissioning plan.** | N/A | | | | | | Not Applicable (not a tailings dam) | | |
| | 3.1d | **Qualified personnel shall be used for the operation, maintenance and surveillance of a dam.** | | X | | | | | No documentation defining training and qualifications for operators relating to dam safety. | | |
| | 3.1e | **Adequate records shall be maintained.** | | | | X | | | Dam safety records are apparently retained, but there is no evidence of review and analysis of measurements | | |
| **3.2** | **OPERATION** | | | | | | | | | | |
| **3.2.1** | **Design Information** | | | | | | | | | | |
| | 3.2.1a | **The operation of the dam shall not violate any important design assumptions that could impair the safety of the dam.** | X | | | | | | | | |
| **3.2.2** | **Flood Operating Procedures** | | | | | | | | | | |
| | 3.2.2a | **During the flood season, a sufficient number or capacity of gates and facilities necessary for discharging flows up to the Inflow Design Flood (IDF) shall be maintained in operable condition** | N/A | | | | | | Discharge facility is an overflow weir with no mechanical moving parts.. | | |
| | 3.2.2b | **Procedures for safe operation and any restrictions for gate operation shall be documented. The procedures shall list all operating restrictions, including drawdown so that any flows up to and including the IDF can be routed in a safe and consistent manner.** | N/A | | | | | | | | |
| | 3.2.2c | **The reservoir shall be operated in accordance with the documented procedures** | X | | | | | | | | |
| **3.2.3** | **Emergency Operating Procedures** | | | | | | | | | | |
| | 3.2.3a | **Procedures for reservoir control and discharge in the case of a developing breach or potential breach, and for any emergency drawdown of the reservoir shall be established.** | X | | | | | | Run of river plant with no storage reservoir and no drawdown capability. Flow reduction is by upstream plants | | |
| **3.2.4** | **Ice and Debris Handling** | | | | | | | | | | |
| | 3.2.4a | **Where reservoirs can contain significant quantities of ice or debris, procedures shall be established for safely handling ice and/or debris.** | X | | | | | | Discharge facility is an overflow weir with no mechanical moving parts.. | | |
| **3.2.5** | **Flood Forecasting** | | | | | | | | | | |
| | 3.2.5a | **The source of any flood forecasting information shall be identified.** | X | | | | | | | | |
| **3.2.6** | **Water Balance for Tailings Basins** | | | | | | | | | | |
| | 3.2.6a | **For tailings basins, the water balance shall be reviewed on a periodic basis, at least annually, to ensure safe operation during flood or drought conditions.** | N/A | | | | | | Not applicable, not a tailings dam | | |
| **3.3** | **MAINTENANCE** | | | | | | | | | | |
| | 3.3a | **Maintenance policies, procedures, records and responsibilities shall be developed and implemented to ensure that the dam, together with applicable structures and equipment required for flood discharge, is maintained in a safe and fully operable condition.** | | | X | | | Snare Hydro OMS manual | Responsibility for dam safety currently not defined | | |
| | 3.3b | **All Equipment related to dam safety shall be inspected and tested at regular intervals to ensure safe and reliable operation.** | X | | | | | Annual intake gate testing required by OMS manual. | Intake gate tested annually and discharge facility is an overflow weir with no mechanical moving parts. | | |
| **3.4** | **SURVEILLANCE** | | | | | | | | | | |
| **3.4.1** | **Standards** | | | | | | | | | | |

## Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.4.1a | **Standards shall be established for each dam to cover inspections, monitoring of fluid-retaining structures, and testing of discharge facilities.** | X | | | | | Snare Hydro OMS manual | | | |
| | 3.4.1b | **The level of surveillance shall be based on the Consequence classification of the dam.** | X | | | | | | | | |
| 3.4.2 | **Regular Inspections** | | | | | | | | | | |
| | 3.4.2a | **In order to obtain baseline data, an initial inspection shall be performed on a new dam prior to the commencement of initial filling.** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 3.4.2b | **Periodic inspections shall be performed to determine the condition of integral portions of the fluid-retaining structure.** | | | | X | | | OMS manual specifies frequent inspections but inspection records were not available for review. | | |
| | 3.4.2c | **Appropriate investigations, as outlined in Section 2, shall be undertaken of all potential deficiencies disclosed by the regular inspections.** | X | | | | | 2000 DSR Report | NTPC initiated additional investigations based on the 2000 DSR recommendations. | | |
| | 3.4.2d | **Annual inspections shall be made of all operating tailings dams** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| 3.4.3 | **Special Inspections** | | | | | | | | | | |
| | 3.4.3a | **Special inspections shall be performed following potentially damaging events.** | X | | | | | | No known potentially damaging events | | |
| 3.4.4 | **Instrumentation** | | | | | | | | | | |
| | 3.4.4a | **Initial readings of all instruments shall be made and formalized as baseline data** | N/A | | | | | | No installed instruments | | |
| | 3.4.4b | **Instrumentation shall be monitored, evaluated and maintained, and the data shall be compared with the previous readings and expected design values.** | N/A | | | | | | | | |
| 3.4.5 | **Tests** | | | | | | | | | | |
| | 3.4.5a | **All operating equipment and facilities necessary to pass the IDF shall be inspected and tested annually to ensure that they will function as required.** | X | | | | | | Intake gate tested annually, Spillway is an overflow weir with no equipment. | | |
| | . | | | | | | | | | | |
| **4.0** | **EMERGENCY PREPAREDNESS** | | | | | | | | | | |
| 4.1 | **GENERAL** | | | | | | | | | | |
| | 4.1a | **Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken** | X | | | | | Snare EPP | | | |
| | 4.1b | **An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream o downstream damage.** | X | | | | | Snare EPP | | | |
| | 4.1c | **A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.** | X | | | | | Snare EPP | The notification process received an operational test in 2006 when Freeboard Dyke 1 near Snare Forks failed due to overtopping. | | |
| | 4.1d | **Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.** | X | | | | | Snare EPP | | | |
| 4.2 | **EMERGENCY PREPAREDNESS PLAN** | | | | | | | | | | |
| 4.2.1 | **Development of an EPP** | | | | | | | | | | |
| | 4.2.1a | **An EPP shall describe the actions to be taken by the dam owner and operator in an emergency. The EPP shall assign responsibility for each action to an individual (identified by organizational position) and/or backup.** | X | | | | | Snare EPP | | | |
| | 4.2.1b | **Input from, and interfaces with, other agencies and affected parties shall be included in the EPP, as appropriate.** | X | | | | | Snare EPP | | | |
| | 4.2.1c | **Copies of the EPP, or summaries of relevant information shall be provided to those who have responsibilities under the plan.** | X | | | | | Snare EPP | | | |
| 4.2.2 | **Contents of an EPP** | | | | | | | | | | |
| | 4.2.2a | **The EPP shall include the following procedures and information:** | | | | | | | | | |
| | 4.2.2a.1 | **- Emergency notification and evaluation:** | | | | X | | | Needs updating and better organization | | |
| | 4.2.2a.2 | **- Preventative actions (where available);** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.3 | **- Notification procedure;** | | | | X | | | Needs updating and better organization | | |
| | 4.2.2a.4 | **- Notification flowchart;** | | X | | | | | Needs updating and better organization | | |
| | 4.2.2a.5 | **- Communication systems;** | X | | | | | | | | |

# Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

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| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.2.2a.6 | **- Access to site;** | X | | | | | | | | |
| | 4.2.2a.7 | **- Response during periods of darkness;** | X | | | | | | | | |
| | 4.2.2a.8 | **- Response during periods of adverse weather;** | X | | | | | | | | |
| | 4.2.2a.9 | **- Sources of equipment;** | | X | | | | | | | |
| | 4.2.2a.10 | **- Stockpiling supplies and materials;** | | X | | | | | | | |
| | 4.2.2a.11 | **- Emergency power sources, if required;** | | X | | | | | | | |
| | 4.2.2a.12 | **- Inundation maps;** | | | | X | | | Add inundation maps | | |
| | 4.2.2a.13 | **- Warning systems (if used).** | | X | | | | | | | |
| **4.2.3** | | **Maintenance and Testing of the EPP** | | | | | | | | | |
| | 4.2.3a | **The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated** | | | X | | | | Distribution appears to be unregulated | | |
| | 4.2.3b | **The EPP shall be tested.** | | | X | | | | No documentation of annual testing but the EPP received the equivalent of a test during the 2006 dyke breach at Snare Forks. | | |
| | 4.2.3c | **For dams under construction, the EPP shall be reviewed annually and updated as appropriate** | N/A | | | | | | Not applicable (dam already built) | | |
| **4.2.4** | | **Training** | | | | | | | | | |
| | 4.2.4a | **Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties.** | | | | X | | | No documentation of operator training available for review. | | |
| **4.3** | | **INUNDATION STUDIES** | | | | | | | | | |
| | 4.3a | **A dam breach inundation study shall be carried out for all dams that clearly require EPPs (see Section 4.1) and for dams where it is not obvious whether or not an EPP is needed** | X | | | | | | | | |
| | 4.3b | **The inundation study shall be based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions** | X | | | | | | | | |
| **5.0** | | **EARTHQUAKES** | | | | | | | | | |
| | 5.0a | **Dams shall be designed and evaluated to withstand ground motions associated with a Maximum Design Earthquake (MDE), without release of the reservoir.** | X | | | | | | | | |
| | 5.0b | **Selection of the MDE for a dam shall be based on the consequences of dam failure.** | X | | | | | | | | |
| **6.0** | | **FLOODS** | | | | | | | | | |
| **6.1** | | **GENERAL** | | | | | | | | | |
| | 6.1a | **Dams shall be designed and evaluated to safely pass an Inflow Design Flood (IDF). Selection of the IDF for a dam shall be based on the consequences of failure.** | X | | | | | | | | |
| | 6.1b | **For new dams with very high or high consequences of failure, the maximum design floods at the dam site shall be evaluated by both statistical analysis and deterministic methods** | N/A | | | | | | Not applicable, not a new dam. | | |
| **6.2** | | **STATISTICAL FLOOD ANALYSIS** | | | | | | | | | |
| | 6.2a | **If the IDF is statistically determined, the reliability of existing statistical flood analysis shall be confirmed or a new statistical flood analysis shall be developed** | X | | | | | This report | | | |
| | 6.2b | **If an unusual event has been recorded since the statistical flood was evaluated, or if the duration of the available hydrological data has increased by more than 50%, a new statistical flood analysis shall be carried out.** | N/A | | | | | | No new hydrological events occurred since previous evaluation; data since 2000 reviewed for this report. | | |
| **6.3** | | **PROBABLE MAXIMUM FLOOD (PMF)** | | | | | | | | | |
| | 6.3a | **A Probable Maximum Flood (PMF) study shall consider the most severe "reasonably possible" combination of the following phenomena on the watershed upstream of the structure under study** | N/A | | | | | | IDF < PMF | | |
| | 6.3a.1 | **- Rainstorm;** | N/A | | | | | | | | |
| | 6.3a.2 | **- Snow accumulation;** | N/A | | | | | | | | |
| | 6.3a.3 | **- Melt rate;** | N/A | | | | | | | | |
| | 6.3a.4 | **- Initial basin conditions (e.g. soil moisture, lake and river levels);** | N/A | | | | | | | | |
| | 6.3a.5 | **- Prestorm.** | N/A | | | | | | | | |
| | 6.3b | **When the PMF is identified as the IDF for a particular project, the acceptability of any previous PMF analysis must be confirmed or a new PMF analysis undertaken.** | N/A | | | | | | | | |
| **7.0** | | **DISCHARGE FACILITIES** | | | | | | | | | |
| **7.1** | | **FLOW CAPACITY OF HYDRAULIC STRUCTURES** | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.1a | **The discharge facilities shall be designed or modified to be capable of passing the IDF, taking into account the routing effect of the reservoir, without the reservoir level infringing on the freeboard established in Section 7.2 for this condition.** | X | | | | | | | | |
| | 7.1b | **New dams shall be designed such that:** | N/A | | | | | **Not applicable - not a new dam** | | | |
| | 7.1b.1 | **- The outflow structure handles ice and debris**; | N/A | | | | | **Ditto** | | | |
| | 7.1b.2 | **- Water conveyance structures resist the anticipated high velocities** | N/A | | | | | **Ditto** | | | |
| | 7.1b.3 | **- Energy dissipation structures protect the dam during the passages of the IDF** | N/A | | | | | **Ditto** | | | |
| 7.2 | FREEBOARD | | | | | | | | | | |
| | 7.2a | **Sufficient freeboard shall be provided so that under all operating conditions, including those during extreme floods or extreme wind conditions the percentage of waves that could overtop the dam is limited to an amount that would not lead to dam failure.** | | | X | | | **2000 DSR** | 2000 DSR did not address freeboard requirememts at Cascades. Freeboard study recommended to document adequacy. | | |
| | 7.2b | **The maximum reservoir level shall be at or below the top of the impervious core for embankment dams.** | X | | | | | | Core consists of a concrete cut-off wall within rockfill dyke. | | |
| 7.3 | OPERATION DURING FLOODS | | | | | | | | | | |
| | 7.3a | **All discharge facilities shall be operated at all times according to a set of pre-determined rules. The development of such rules shall consider the safe passage of all hydrological events, including the IDF** | X | | | | | | | | |
| | 7.3b | **For new dams, rule curves shall be established for operation during the flood season, such that all floods, including the IDF, can be passed safely**. | N/A | | | | | | Not applicable (not a new dam) | | |
| 7.4 | OPERATION OF FLOW CONTROL EQUIPMENT | | | | | | | | | | |
| | 7.4a | **The conditions under which the spillway, discharge facilities and power intake must operate, as well as the level of automation associated with the equipment, shall be determined on a site-specific basis.** | X | | | | | | Discharge facility is an overflow weir with no mechanical moving parts. | | |
| | 7.4b | **All flow control equipment shall be designed to be capable of opening and closing under required operating conditions. The required service shall be determined by a site-specific evaluation of requirements.** | X | | | | | | Discharge facility is an overflow weir with no mechanical moving parts. | | |
| 7.5 | INSTRUMENTATION AND CONTROL | | | | | | | | | | |
| | 7.5a | **Equipment on Very High and High Consequence structures shall be provided with instrumentation to enable local and/or remote monitoring of conditions at the hydraulic structures** | N/A | | | | | | | | |
| 7.6 | EMERGENCY EQUIPMENT | | | | | | | | | | |
| | 7.6a | **As a minimum, emergency power equipment shall be available for installation in a reasonable amount of time at Very High and High Consequence structures. Otherwise, permanent emergency power equipment shall be installed.** | N/A | | | | | | Discharge facility is an overflow weir with no mechanical moving parts. | | |
| | 7.6b | **Controls and instrumentation shall permit operation and monitoring during power outage conditions for Very High and High Consequence structures.** | N/A | | | | | | Discharge facility is an overflow weir with no mechanical moving parts. | | |
| 8.0 | GEOTECHNICAL CONSIDERATIONS | | | | | | | | | | |
| 8.1 | GEOTECHNICAL INVESTIGATIONS FOR NEW DAMS | | | | | | | | | | |
| | 8.1a | **Adequate geotechnical investigations shall be carried out on the site selected for a new dam** | N/A | | | | | | | | |
| | 8.1b | **A permanent record or log shall be kept of all inspections, investigation reports, drawings and design reports.** | X | | | | | | | | |
| 8.2 | EMBANKMENT DAMS AND SOIL FOUNDATIONS | | | | | | | | | | |
| 8.2.1 | Monitoring and Instrumentation | | | | | | | | | | |
| | 8.2.1a | **Sufficient instrumentation for the embankment dam and foundation shall be provided, commensurate with the Consequence Category, so that the performance can be adequately monitored and dam safety can be evaluated.** | | X | | | | | No instrumentation. Rockfill dam on rock foundation. | | |
| | 8.2.1b | **For new dams, sufficient instrumentation shall be provided to adequately monitor the dam and evaluate its performance.** | N/A | | | | | | Not applicable. Not a new dam. | | |
| 8.2.2 | Stability and Deformation | | | | | | | | | | |
| | 8.2.2a | **The slopes of the dam and the abutment shall be designed so that the dam, foundation and abutments are stable under all stages of construction, reservoir levels and operating conditions.** | X | | | | | | Approach channel dyke is a low structure designed with conservative slopes. No stability issues identified | | |
| | 8.2.2b | **The slopes of the dam and the abutment shall be designed not to cause unacceptable deformation in the dam or foundation.** | X | | | | | | Rock foundation. | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

# Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.2.2c | **The stability of reservoir slopes shall be evaluated under seismic loads, heavy rainfall, rapid drawdown and any other conditions, if slope failure could induce waves that pose an unacceptable risk to public safety, the dam or its appurtenant structures.** | X | | | | | | Run of river plant, limited reservoir rim. | | |
| | 8.2.2d | **If necessary, such slopes shall be stabilized or the public otherwise protected from the effects of slope failure.** | N/A | | | | | | Condition not applicable | | |
| | 8.2.2e | **Any material stockpiled upstream of a tailings dam shall be maintained in a stable configuration, if it can affect the stability of the dam or its appurtenant structures either directly or by destabilising stored or stockpiled tailings.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| | 8.2.2f | **Sufficient freeboard shall be provided to accommodate expected settlement of the crest and cracks caused by frost action.** | N/A | | | | | | Concrete cutoff on rock. | | |
| **8.2.3** | **Seepage and Drainage Control** | | | | | | | | | | |
| | 8.2.3a | **Filters shall be placed between materials where otherwise significant migration of particles by seepage forces would be possible.** | N/A | | | | | | No filters or drains provided, or necessary. | | |
| | 8.2.3b | **Construction of embankments, structural cutoffs and foundation treatment shall be staged such that adequate filters are in place.** | N/A | | | | | | | | |
| | 8.2.3c | **Filter provisions shall be adequate to accommodate the movements and avoid erosion induced by the design earthquake.** | N/A | | | | | | | | |
| | 8.2.3d | **The hydraulic gradients in the dam, in foundation abutments and along conduits, shall be low enough to prevent piping and heave in the existing material.** | N/A | | | | | | | | |
| | 8.2.3e | **The flow capacity of filters and drains shall be designed to accommodate the maximum anticipated seepage.** | N/A | | | | | | | | |
| **8.2.4** | **Cracking** | | | | | | | | | | |
| | 8.2.4a | **The dam shall be designed to retain the reservoir safely in spite of any cracking that may be induced by settlement or hydraulic fracturing.** | X | | | | | | There is no evidence that excessive settlement or hydraulic fracturing has occurred. Cracks have not been identified in the past. | | |
| **8.2.5** | **Surface Erosion** | | | | | | | | | | |
| | 8.2.5a | **The upstream slopes of the dam and its abutments shall be provided with adequate protection to guard against erosion and possible breaching due to wave and ice action and against burrowing animals such as beaver and muskrat. Failure of riprap must not result in dam failure.** | X | | | | | | | | |
| | 8.2.5b | **The downstream slopes shall be protected where necessary against the erosive action of runoff, seepage flows, traffic, frost and burrowing animals.** | X | | | | | | | | |
| | 8.2.5c | **Inlet and outlet channels for spillways and conduits shall be adequately protected against erosion.** | | | X | | | | Erosion occurring above FSL at the right abutment of the labyrinth spillway. | | |
| | 8.2.5d | **Temporary and permanent slopes of the embankments and abutments shall be adequately protected against wave action, runoff and seepage flows during construction** | N/A | | | | | | | | |
| **8.2.6** | **Liquefaction** | | | | | | | | | | |
| | 8.2.6a | **All embankment and foundation materials susceptible to liquefaction shall be identified** | N/A | | | | | | Rockfill on rock foundation. | | |
| | 8.2.6b | **If liquefaction is possible under static conditions or probable under design earthquake loading, the post-liquefaction stability of the dam shall be evaluated** | N/A | | | | | | Ditto | | |
| | 8.2.6c | **If unacceptable flowsliding is probable following liquefaction, appropriate remedial measures shall be undertaken to ensure dam failure does not occur.** | N/A | | | | | | Ditto | | |
| **8.2.7** | **Earthquake Resistance** | | | | | | | | | | |
| | 8.2.7a | **The dam, appurtenant structures, foundation and abutments shall be designed to resist the forces associated with the Maximum Design Earthquake (MDE).** | X | | | | | | MDE is low. No stability issues identified | | |
| | 8.2.7b | **Embankments and foundations that are required to impound temporary reservoirs during construction shall be designed to resist forces associated with the MDE selected for their design** | N/A | | | | | | | | |
| **8.3** | **DAMS ON ROCK FOUNDATIONS** | | | | | | | | | | |
| **8.3.1** | **Foundation Stability** | | | | | | | | | | |
| | 8.3.1a | **For new dams rock foundations shall be excavated to a depth, and grouted, such that they have sufficient strength, watertightness and stiffness:** | N/A | | | | | | Not a new dam. | | |
| | 8.3.1a.1 | **- to support all stages of construction and initial reservoir filling and drawdowr** | N/A | | | | | | | | |
| | 8.3.1a.2 | **- to provide adequate stability under design loads for the dam, appurtenances, abutments and foundatio** | N/A | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

# Table 14-4: 2006 Dam Safety Review
# Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, bold text "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.3.1a.3 | **- to limit deformations to acceptable values.** | N/A | | | | | | | | |
| 8.3.2 | | **Shear Strength Parameters** | | | | | | | | | |
| | 8.3.2a | **The dam shall be designed such that the shear strength of the rock foundations is adequate at all stages of construction, initial reservoir filling and drawdown, to ensure the stability of a dam at and within its foundation.** | | X | | | | | Satisfactory operating history of dam indicates that foundation is adequate. | | |
| 8.3.3 | | **Seepage and Drainage** | | | | | | | | | |
| | 8.3.3a | **If the rock is not of sufficient quality, adequate protection shall be provided to protect against internal erosion, leaching, or solution effects in foundations or abutments** | N/A | | | | | | Rock appears sound. | | |
| | 8.3.3b | **The foundation and abutment grouting and drainage systems shall maintain foundation water pressures at acceptable levels.** | N/A | | | | | | | | |
| | 8.3.3c | **Where embankments are constructed on rock foundations, the treatment of the foundation shall be compatible with the embankment materials, such that migration of the embankment material is prevented** | X | | | | | | | | |
| | 8.3.3d | **Provision shall be made to control unacceptable quality and quantity of seepage for all stages of construction, initial reservoir filling, operation and drawdown.** | X | | | | | | | | |
| 8.4 | | **<u>DAMS ON PERMAFROST</u>** | | | | | | | | | |
| | 8.4a | **Dams on permafrost shall meet the same stability requirements as other embankment dams, and shall remain stable in spite of large foundation settlements.** | N/A | | | | | | Rock foundation. | | |
| | 8.4b | **The freeboard shall be adequate to accommodate the expected settlement** | N/A | | | | | | | | |
| | 8.4c | **The fill zones shall have sufficient integrity to prevent piping and limit seepage to an acceptable amount.** | N/A | | | | | | | | |
| 8.5 | | **<u>APPURTENANT STRUCTURES</u>** | | | | | | | | | |
| 8.5.1 | | **Foundation Movement** | | | | | | | | | |
| | 8.5.1a | ***In situ* foundations and abutments as well as embankments and backfill, through which or on which an appurtenant hydraulic structure will be constructed, should be designed to be free from gravity-driven movements that would impair the operational capability of the structure or lead to structural damage such as excessive cracking, deformation, deflection, damage to joints, threaten the structural integrity and hydraulic performance. Likewise, the foundations and embankment shall be protected from any potential adverse effects of any leakage from any conduit or structures.** | | X | | | | | No record of movements of appurtenant structures or abutments. | | |
| | 8.5.1b | **The foundation of an appurtenant hydraulic structure, whether *in situ* or compacted earthen materials, shall be designed to avoid differential settlement or heave that would either damage seals, waterstops or joints, or misalign or crack slabs or monoliths** | | X | | | | | Intake structure constructed on bedrock. | | |
| 8.5.2 | | **Slope Stability** | | | | | | | | | |
| | 8.5.2a | **Slopes flanking the approach and exit channels of an appurtenant hydraulic structure shall be designed to be stable to the extent that any instability under the broad category of gravity-driven soil and rock movement does not restrict these channels.** | | X | | | | | Slopes excavated in rock. No observation or report of instability in the past | | |
| 8.5.3 | | **Seepage** | | | | | | | | | |
| | 8.5.3a | **The impervious or seepage-control zone immediately underlying or enclosing the upstream portion of an appurtenant hydraulic structure, including components such as cut-off, core trench or upstream blanket shall be designed to be free of localised concentrations of seepage that could lead to piping. In the case of new dams, this impervious or seepage-control zone shall be free of deleterious hydraulic and material conditions which individually or in combination could lead to excessive seepage and piping** | | X | | | | | Performance record indicates adequate seepage control at control structures. | | |
| 8.6 | | **<u>GABION, ROCK CRIB AND TIMBER STRUCTURES</u>** | | | | | | | | | |
| | 8.6a | **Gabion, rock crib and timber dams, and their foundations, shall meet the same stability requirements as all dams. In addition, the timber shall maintain durability and be capable of transmitting the induced loads** | N/A | | | | | | | | |
| | 8.6b | **Gabion dams shall incorporate a suitable filter as a preventive measure against undermining of the foundation soil material. The wire comprising the gabion mesh shall be adequately sized and protected against corrosion and shall be designed to retain its integrity for the planned life of the structure** | N/A | | | | | | | | |
| 8.7 | | **<u>MEMBRANE-FACED ROCKFILL DAMS</u>** | | | | | | | | | |
| | 8.7a | **Membrane-faced rockfill dams and their foundations shall meet the same stability requirements as other embankment dams. The integrity of the upstream membrane shall be designed to minimize the effects of settlement, ultraviolet deterioration and any other damage that would permit excessive leakage** | N/A | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

## Table 14-4: 2006 Dam Safety Review
## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.7b | **Seepage or leakage through the membrane face shall be limited to values that will not adversely affect dam stability.** | N/A | | | | | | | | |
| 8.8 | | **FLOW-THROUGH ROCKFILL DAMS** | | | | | | | | | |
| | 8.8a | **For the design flood, flow-through rockfill dams shall be designed to withstand the combined effects of the action of the seepage emerging from the downstream face, along with any overflow without local or massive movement of rock particles.** | N/A | | | | | | | | |
| 9.0 | | **CONCRETE STRUCTURES** | | | | | | | | | |
| 9.1 | | **GENERAL** | | | | | | | | | |
| | 9.1a | **The level of design or safety assessment for concrete dams and other water-retaining structures shall take into account the consequences of failure of the structure** | X | | | | | Monenco Agra Drawings; 2000 DSR; this report | LOW Consequence Category Structures | Designed to recent codes by a reputable consultant | |
| 9.2 | | **CONDITION OF STRUCTURES AND SITES** | | | | | | | | | |
| | 9.2a | **The strength and condition of the dam and foundation shall be determined to the extent required for the design of a new dam or analysis of an existing dam.** | | X | | | | | See 9.1a | | |
| | 9.2b | **If the concrete appears to be damaged or weakened, tests shall be carried out to determine its strength parameters, or suitably conservative assumptions made in the analysis of its safety** | | X | | | | 2000 DSR, this report | | | |
| | 9.2c | **For High and Very High Consequence dams, sufficient instrumentation shall be provided for the structure and foundation, to allow performance to be monitored and safety to be evaluated.** | N/A | | | | | | | | |
| 9.3 | | **LOADS** | | | | | | | | | |
| | 9.3a | **The following loads shall be considered in the design or assessment of concrete structures** | | X | | | | | See 9.1a | | |
| | 9.3a.1 | **- Dead loads of permanent structures and equipment (D):** | | X | | | | | | | |
| | 9.3a.2 | **- Maximum normal headwater level (H) combined ,with the most critical concurrent tailwater level** | | X | | | | | | | |
| | 9.3a.3 | **- Maximum flood headwater level ($H_F$) based on the Inflow Design Flood (IDF) with corresponding tailwater levels;** | | X | | | | | | | |
| | 9.3a.4 | **- Internal water pressure and foundation uplift (U);** | | X | | | | | | | |
| | 9.3a.5 | **- Static and dynamic thrust created by an ice sheet, for reservoirs subject to freezing (I)** | | X | | | | | | | |
| | 9.3a.6 | **- Vertical and horizontal loading due to rock or soil backfill, including potential effects of liquefaction, as well as loads from silt deposited against the structure (S);** | | X | | | | | | | |
| | 9.3a.7 | **- Maximum Design Earthquake (Q);** | | X | | | | | | | |
| | 9.3a.8 | **- Temperature-induced loads (T), for stability and stress analysis of concrete structures with grouted contraction joints especially buttress and arch dams.** | N/A | | | | | | | | |
| 9.4 | | **LOAD COMBINATIONS** | | | | | | | | | |
| 9.4.1 | | **Usual Loading** | | | | | | | | | |
| | 9.4.1a | **Permanent and operating loads shall be considered for both summer and winter conditions including self-weight, ice, silt, earth pressure, and the normal maximum operating water level with appropriate uplift pressures and tailwater leve (D+H+I+S+U).** | | X | | | | | See 9.1a | | |
| 9.4.2 | | **Unusual Loading** | | | | | | | | | |
| | 9.4.2a | **Where earthquake-induced cracking at the rock concrete interface or any weak section is identified, a stability analysis shall be carried out to see whether the structure in its post-earthquake condition is still capable of resisting the Usual Loading ($D+H+S+U_{PQ}$).** | | X | | | | | See 9.1a | | |
| 9.4.3 | | **Flood Loading** | | | | | | | | | |
| | 9.4.3a | **Permanent and operating loads of the Usual Loading, except for ice loading, shall be considered in conjunction with reservoir and tailwater levels and uplift resulting from the passage of the Inflow Design Flood (IDF) ($D+H_F+S+U_F$).** | | X | | | | | See 9.1a | | |
| 9.4.4 | | **Earthquake Loading** | | | | | | | | | |
| | 9.4.4a | **Permanent and operating loads of the Usual Loading case shall be considered in conjunction with the seismic loads of the Maximum Design Earthquake (MDE) ($D+H+S+Q+U_Q$).** | | X | | | | | See 9.1a | | |
| 9.4.5 | | **Temperature Loading** | | | | | | | | | |
| | 9.4.5a | **Permanent and operating loads from the Usual Loading case shall be considered in conjunction with temperature loads for buttress and arch dams (D+H+I+S+U+T).** | N/A | | | | | | | | |
| 9.5 | | **DESIGN AND ANALYSIS** | | | | | | | | | |
| | 9.5a | **Concrete dams shall be designed to resist and prevent:** | | X | | | | | See 9.1a | | |
| | 9.5a.1 | **- Sliding at the dam-foundation interface, within the dam and at any plane in the foundation** | | X | | | | | | | |
| | 9.5a.2 | **- Overturning;** | | X | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

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## Conformance of Snare Cascades with CDA Dam Safety Guidelines

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.5a.3 | **- Overstressing of the concrete dam or foundation**; | | X | | | | | | | |
| | 9.5a.4 | **- Excessive seepage through the foundation or through joints in the concrete dam** | | X | | | | | | | |
| | 9.5b | **Safety analyses for existing concrete dams shall take into account their ability to resist and prevent the above conditions.** | | X | | | | | | | |
| | 9.5c | **Stresses and stability of a concrete gravity dam shall be evaluated for ground motions in the upstream-downstream direction. If the geometry suggests potential "pounding" of adjacent blocks, cross-valley analyses shall be undertaken.** | | X | | | | | | | |
| | 9.5d | **Stresses and stability of a buttress dam shall be evaluated for ground motions in the upstream-downstream as well as the cross-valley directions**. | | X | | | | | | | |
| **9.6** | **PERFORMANCE INDICATORS** | | | | | | | | | | |
| | 9.6a | **The design and assessment of concrete dams and other water-retaining structures shall be based on performance indicators such as:** | | X | | | | | See 9.1a | | |
| | 9.6a.1 | **- Position of resultant force;** | | X | | | | | | | |
| | 9.6a.2 | **- Normal stresses at the heel and the toe;** | | X | | | | | | | |
| | 9.6a.3 | **- Average shear stresses acting on the surface**; | | X | | | | | | | |
| | 9.6a.4 | **- Calculated sliding factors and strength factors**; | | X | | | | | | | |
| | 9.6a.5 | **- Observed conditions of structure and site**. | X | | | | | 2000 DSR, this report | | | |
| **9.7** | **ACCEPTANCE CRITERIA** | | | | | | | | | | |
| | 9.7a | **Concrete gravity, buttress and arch dams and their foundations shall have adequate sliding resistance to withstand all reasonable loads and load combinations that could occur** | | X | | | | | See 9.1a | | |
| | 9.7b | **The concrete must have sufficient strength that the loads will not result in excessive deformations or overstressing.** | | X | | | | | See 9.1a | | |
| | 9.7c | **During and after extreme events such as the IDF and the MDE, the dam shall continue to safely retain the reservoir water.** | | X | | | | | See 9.1a | | |
| | 9.7d | **The level of safety of appurtenant structures shall be compatible with the consequences of their failure.** | N/A | | | | | | No concrete appertunance structures governed by DSR requirements | | |
| | 9.7e | **The effects of static and dynamic (seismic) loadings on support structures for mechanical and electrical equipment that relate to dam safety shall be examined to ensure that structural integrity and functionality are preserved.** | | X | | | | | Not assessed but MDE is low | | |
| **9.8** | **ROLLER-COMPACTED CONCRETE (RCC) DAMS** | | | | | | | | | | |
| | 9.8a | **Roller-compacted concrete (RCC) dams shall meet the same stability and performance specifications as conventional concrete gravity dams.** | | | | | | N/A | | | |
| **10.0** | **RESERVOIR AND ENVIRONMENT** | | | | | | | | | | |
| **10.1** | **RESERVOIR DEBRIS AND ICE** | | | | | | | | | | |
| | 10.1a | **Reservoir debris and ice shall be managed in such a way that they do not constitute an unacceptable risk to dam safety.** | X | | | | | | Performance record indicates adequate debris and ice management. | | |
| **10.2** | **RESERVOIR RIM** | | | | | | | | | | |
| | 10.2a | **Unstable slopes or slopes which are potentially unstable under extreme loading, or rapid reservoir drawdown conditions around the reservoir rim shall be monitored and treated if necessary so that they do not constitute an unacceptable risk to the safety of the dam** | N/A | | | | | | | | |
| | 10.2b | **Any point on the rim of the reservoir which forms a natural barrier shall be treated in the same manner as a dam, if its failure could release the reservoir.** | N/A | | | | | | | | |
| | 10.2c | **Excessive seepage through the reservoir rim shall be controlled so that it does not constitute an unacceptable risk to the safety of the dam or reservoir**. | N/A | | | | | | | | |
| **10.3** | **WATER QUALITY** | | | | | | | | | | |
| | 10.3a | **Consideration shall be given to monitoring detrimental effects on structural elements of the dam from chemical interaction between groundwater, reservoir water, natural soil, and all dam materials, and to taking necessary protective measures.** | X | | | | | | No report of water quality issue in many years of operation. | | |
| **10.4** | **SEDIMENTATION AND SILTING** | | | | | | | | | | |
| | 10.4a | **Silt deposition near the dam and discharge facilities shall be monitored as appropriate and if the continued deposition could impair the safe routing of floods or the stability of the dam, appropriate remedial measures shall be taken.** | X | | | | | | | | |

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## Conformance of Snare Cascades with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10.4b | **Tailings shall not be deposited in such a manner as to hinder the operation or stability of a dam and its appurtenant structures.** | N/A | | | | | | No evidence of siltation at any structure. | | |
| **10.5** | **RESERVOIR DRAWDOWN CAPABILITY** | | | | | | | | | | |
| | 10.5a | **At dams that are subject to severe damage by earthquake or landslides, or where a high potential for internal erosion exists, outlet facilities shall be provided to quickly lower the reservoir to a safe level for the dam in its damaged state.** | N/A | | | | | | Run of river facility | | |
| **10.6** | **ECOLOGY** | | | | | | | | | | |
| | 10.6a | **The dam shall be monitored for dam safety hazards presented by animals, birds, vegetation or other organisms, and protective action taken if required.** | X | | | | | | Maintenance required locally to remove vegetation. | | |
| **10.7** | **REHANDLING OF TAILINGS** | | | | | | | | | | |
| | 10.7a | **The rehandling of tailings or other materials upstream of, or adjacent to a dam, shall be undertaken in such a manner that the safety or safe operation of a dam and appurtenances is not impaired** | N/A | | | | | | | | |
| **11.0** | **CONSTRUCTION** | | | | | | | | | | |
| | 11a | **An Engineer shall ensure that the project specifications are strictly adhered to. Any deviation from the prescribed specifications are allowed only if approved by the design engineer** | N/A | | | | | | | | |
| | 11b | **The Engineer shall document and approve all phases of the project construction** | N/A | | | | | | | | |
| | 11c | **Temporary construction facilities shall be constructed such that there is no adverse impact on the safety of the dam or appurtenant structures.** | N/A | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.



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# Table 14-5: 2006 Dam Safety Review
# Conformance of Snare Forks with CDA Dam Safety Guidelines

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | . | | | | | | | | | | |
| **1.0** | **SCOPE, DEFINITIONS AND GENERAL REQUIREMENTS** | | | | | | | | | | |
| **1.1** | **SCOPE AND APPLICABILITY OF THE GUIDELINES** | | | | | | | | | | |
| **1.2** | **DEFINITIONS** | | | | | | | | | | |
| **1.3** | **RESPONSIBILITY FOR DAM SAFETY** | | | | | | | | | | |
| **1.3.1** | **General** | | | | | | | | | | |
| | **1.3.1a** | **The responsibility for all aspects of the safety of a dam shall be clearly defined and delegation of responsibility and authority shall be documented.** | | | X | | | Snare Hydro OMS manual | Updating and reorganization of the manuals is required. | | |
| **1.4** | **CLASSIFICATION OF DAMS** | | | | | | | | | | |
| | **1.4a** | **Each dam, water control structure or water passage, shall be classified in terms of the reasonably foreseeable incremental consequences of failure.** | X | | | | | | | | |
| | **1.4b** | **The loss of life consequences shall be evaluated separately from the socioeconomic, financial and environmental consequences and the higher of the two classifications shall be usec** | X | | | | | | | | |
| | **1.4c** | **For new dams, the consequences category shall be established during feasibility studies used for design, and confirme prior to first reservoir filling** | N/A | | | | | | Not a new dam | | |
| **1.5** | **SELECTION OF SAFETY CRITERIA** | | | | | | | | | | |
| | **1.5a** | **The dam, along with its foundation and abutments, shall be designed to have adequate stability to safely withstand extreme loads as well as the normal design loads.** | X | | | | | | | | |
| | **1.5b** | **The selection of loading criteria for extreme loads shall be based on the consequences of failure of the dam** | X | | | | | | | | |
| | **1.5c** | **For tailings dams, the loading criteria or level of safety at any stage of construction shall be commensurate with the consequences of failure at that stage , with due consideration of the consequences at future stages** | N/A | | | | | | Not a tailings dam | | |
| **1.6** | **DECOMMISSIONING AND CLOSURE** | | | | | | | | | | |
| | **1.6a** | **A dam shall be decommissioned and considered closed only when all the requirements of a decommissioning plan hav been complied with.** | N/A | | | | | | | | |
| | **1.6b** | **Demolition of a dam or removal of any of its appurtenances shall be based on sound practice and carried out without increasing the risk of failure of remaining structures and appurtenances or causing adverse impacts downstream of the dam.** | N/A | | | | | | | | |
| | **1.6c** | **Demolition operations shall not result in blockage or reduction of the safe discharge of natural floods. That part of the dam and its appurtenant structures which may obstruct the discharge of the water course or drainage course such that it causes upstream flooding beyond that of the existing dam and appurtenent structures or leads to a sudden release of water, must be completely removed.** | N/A | | | | | | | | |
| | **1.6d** | **Structures that remain after decommissioning shall be physically and chemically stable, and shall not impose an unacceptable risk to public health and safety, or the environment** | N/A | | | | | | | | |
| | **1.6e** | **Closure requirements for tailings dams must be considered and incorporated into the initial design stage and at all subsequent design and construction phases** | N/A | | | | | | | | |
| | **1.6f** | **Any tailings dam that retains contaminated or acid generating materials shall be monitored and maintained, to a level commensurate with the consequences of failure, after infilling is completed or mining operations are terminated.** | N/A | | | | | | | | |
| | . | | | | | | | | | | |
| **2** | **DAM SAFETY REVIEW** | | | | | | | | | | |
| **2.1** | **GENERAL** | | | | | | | | | | |
| | **2.1a** | **A Dam Safety Review (the "Review") shall be carried out by a qualified engineer (the "Engineer") at regular time intervals for dams and associated facilities. The review shall include the design, operation, maintenance, surveillance and emergency plans, to determine if they are safe in all respects and, if they are not, to determine required safety improvements.** | X | | | | | | | | |
| | **2.1b** | **The first Dam Safety Review for a new dam shall be completed within three years of initial filling** | N/A | | | | | | Not the first DSR | | |
| | **2.1c** | **A Dam Safety Review shall be carried out when there are significant changes in the stage of construction of a tailings dam, or the condition of any dam, including:** | N/A | | | | | | See individual comments below | | |
| | **2.1c.1** | **- Major modification to the original design or design criteria** | N/A | | | | | | | | |
| | **2.1c.2** | **- Discovery of an unusual condition;** | N/A | | | | | | Not applicable (no unusual condition prior to DSR) | | |
| | **2.1c.3** | **- Decommissioning;** | N/A | | | | | | Not applicable (facility still in full operation). | | |
| | **2.1c.4** | **- After an extreme hydrological or seismic event.** | N/A | | | | | | Not applicable (no extreme hydrological or seismic events). | | |
| **2.2** | **DETAILS OF REVIEW** | | | | | | | | | | |
| **2.2.1** | **Dam Classification** | | | | | | | | | | |
| | **2.2.1a** | **The Review shall include the classification of the dam, as outlined in Section 1.** | X | | | | | 2000 DSR & this report | | | |
| **2.2.2** | **Site Inspection** | | | | | | | | | | |
| | **2.2.2a** | **The Review shall include an appropriately comprehensive field inspection of the dam and appurtenant structures, and documentation thereof.** | | | | X | | This report | Tunnel not inspected | | Inspect and document tunnel condition when accessible |
| **2.2.3** | **Design and Construction** | | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

## Table 14-5: 2006 Dam Safety Review
## Conformance of Snare Forks with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.2.3a | **The Review of design and construction shall be sufficiently comprehensive to demonstrate whether the dam, discharge facilities and reservoir slopes meet all currently applicable safety requirements** | | | X | | | | Intake stability not able to be reviewed, as records not available | | |
| **2.2.4** | **Operation and Testing** | | | | | | | | | | |
| | 2.2.4a | **The Review shall determine if safe operating procedures have been developed, documented and followed in all respects. The adequacy of the documentation shall be reviewed**. | X | | | | | Snare Hydro OMS manual | | | |
| | 2.2.4b | **The Review shall include the testing of equipment required to operate discharge facilities (including backup equipment and emergency power supply) that are required for the safe passage of the inflow design flood, and any other flood that could endanger the dam, and adequacy of ice and debris control facilities and procedures to verify that they will function as and when required.** | | | | X | | Snare Hydro OMS manual | No record of intake gate testing provided | | |
| **2.2.5** | **Maintenance** | | | | | | | | | | |
| | 2.2.5a | **The Review shall ascertain if all facilities required for safety of the dam, including dam monitoring instrumentation, are maintained in satisfactory condition in accordance with a manual defining the maintenance requirements for dam safety.** | | | | | X | Snare Hydro OMS manual | Freeboard dyke crests not maintained | | |
| **2.2.6** | **Surveillance and Monitoring of Dam Performance** | | | | | | | | | | |
| | 2.2.6a | **The Review shall determine if the surveillance and monitoring methods and frequency are adequate to detect any unsafe condition in a timely manner**. | | | | | X | | Freeboard dyke failure occurred in 2006. | | Annual survey of freeboard dyke crests. |
| | 2.2.6b | **The Review shall determine if monitoring data have been regularly analysed and used to ensure prompt detection of any potentially unsafe conditions in the dam, associated water containment and reservoir slopes.** | | | | | X | | 2005 survey indicated Freeboard Dykes up to 2 m below design grade. No documentation of review, assessment and remediation | | |
| **2.2.7** | **Emergency Preparedness** | | | | | | | | | | |
| | 2.2.7a | **The Review shall determine if the appropriate level of emergency preparedness exists and is adequately documented. The adequacy of warning systems, training and emergency response plans shall be reviewed, as well as testing and updating of plans.** | | | X | | | Snare Hydro Emergency Preparedness Manual | No documentation of plan testing or review. EPP tested in 2006 during actual failure event. Reaction time and response was not sufficient to prevent the failure. | | |
| **2.2.8** | **Compliance with Previous Reviews** | | | | | | | | | | |
| | 2.2.8a | **Previous Dam Safety Reports shall be reviewed to determine compliance with their recommendations** | X | | | | | This report | | | |
| **2.3** | **DAM SAFETY REPORT** | | | | | | | | | | |
| | 2.3a | **A Dam Safety Report ("the Report"), covering all aspects of the dam's safety, shall be prepared, documenting the Dam Safety Review.** | X | | | | | This report | | | |
| | 2.3b | **The Report shall identify any additional steps required for the safe operation, maintenance and adequate surveillance of the dam.** | X | | | | | This report | | | |
| **2.4** | **FAILURE TO MEET REQUIREMENTS** | | | | | | | | | | |
| | 2.4a | **If the dam and/or appurtenant structures fails to meet the safety requirements, safety improvements shall be carried out as appropriate, including:** | | | | | | | | | |
| | 2.4a.1 | **- Safety improvements of the physical facilities**; | | | | | X | | See Table 14.1 | | |
| | 2.4a.2 | **- Nonstructural improvements;** | | | X | | | | See Table 14.1 | | |
| | 2.4a.3 | **- Overcoming any deficiencies in operation, surveillance, inspection or maintenance of the dam, or emergency preparedness.** | | | | | X | | See Table 14.1 | | |
| **3.0** | **OPERATION, MAINTENANCE AND SURVEILLANCE** | | | | | | | | | | |
| **3.1** | **GENERAL** | | | | | | | | | | |
| | 3.1a | **Dam operation, maintenance and surveillance shall be provided so that an acceptable level of dam safety is ensured.** | | | | | X | Snare Hydro OMS Manual | Freeboard Dyke1 failed in 2006. | | |
| | 3.1b | **A manual (the "OMS Manual") shall be prepared, documenting operation, maintenance and surveillance for each applicable dam. The OMS manual shall be implemented, followed, and updated at appropriate intervals. The manual shall contain suitable and sufficient information to allow operators to operate the dam in a safe manner, maintain it in a safe condition, and monitor its performance well enough to provide early signs of any distress.** | | | X | | | Snare Hydro OMS Manual | Updating and reorganization of the manuals is required. | | |
| | 3.1c | **For tailings dams a separate OMS Manual shall be prepared for the closure stage or included in the decommissioning plan.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| | 3.1d | **Qualified personnel shall be used for the operation, maintenance and surveillance of a dam.** | | X | | | | | No documentation defining training and qualifications for operators relating to dam safety. | | |
| | 3.1e | **Adequate records shall be maintained.** | | | | X | | | Intake gate test records not found; inspection reports not available for review. | | |
| **3.2** | **OPERATION** | | | | | | | | | | |
| **3.2.1** | **Design Information** | | | | | | | | | | |
| | 3.2.1a | **The operation of the dam shall not violate any important design assumptions that could impair the safety of the dam.** | | | | | X | | Design crest levels of freeboard dykes not maintained. | | |
| **3.2.2** | **Flood Operating Procedures** | | | | | | | | | | |

## Table 14-5: 2006 Dam Safety Review
## Conformance of Snare Forks with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

**DEFICIENCY = aspect or condition that could (potentially or actually) threaten safety**

| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles** (CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.2.2a | **During the flood season, a sufficient number or capacity of gates and facilities necessary for discharging flows up to the Inflow Design Flood (IDF) shall be maintained in operable condition.** | X | | | | | | The discharge facilities are overflow weirs with no mechanical equipment. The plant intake gates are maintained adequately. | | |
| | 3.2.2b | **Procedures for safe operation and any restrictions for gate operation shall be documented. The procedures shall list all operating restrictions, including drawdown so that any flows up to and including the IDF can be routed in a safe and consistent manner.** | X | | | | | Snare Hydro OMS Manual | Overflow weir for flood passage. | | |
| | 3.2.2c | **The reservoir shall be operated in accordance with the documented procedures** | X | | | | | | | | |
| 3.2.3 | **Emergency Operating Procedures** | | | | | | | | | | |
| | 3.2.3a | **Procedures for reservoir control and discharge in the case of a developing breach or potential breach, and for any emergency drawdown of the reservoir shall be established.** | | | | X | | | The discharge facilities are overflow weirs with no mechanical equipment. Emergency drawdown procedure is to breach dyke #1 | | |
| 3.2.4 | **Ice and Debris Handling** | | | | | | | | | | |
| | 3.2.4a | **Where reservoirs can contain significant quantities of ice or debris, procedures shall be established for safely handling ice and/or debris.** | X | | | | | | | | |
| 3.2.5 | **Flood Forecasting** | | | | | | | | | | |
| | 3.2.5a | **The source of any flood forecasting information shall be identified** | X | | | | | | | | |
| 3.2.6 | **Water Balance for Tailings Basins** | | | | | | | | | | |
| | 3.2.6a | **For tailings basins, the water balance shall be reviewed on a periodic basis, at least annually, to ensure safe operation during flood or drought conditions** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| 3.3 | **MAINTENANCE** | | | | | | | | | | |
| | 3.3a | **Maintenance policies, procedures, records and responsibilities shall be developed and implemented to ensure that the dam, together with applicable structures and equipment required for flood discharge, is maintained in a safe and fully operable condition.** | | | | | X | Snare Hydro OMS Manual | Design level of freeboard dykes not maintained. Responsibility for dam safety not clear. | | |
| | 3.3b | **All Equipment related to dam safety shall be inspected and tested at regular intervals to ensure safe and reliable operation.** | | X | | | | Snare Hydro OMS Manual | Overflow weir, no mechanical equipment. | | |
| 3.4 | **SURVEILLANCE** | | | | | | | | | | |
| 3.4.1 | **Standards** | | | | | | | | | | |
| | 3.4.1a | **Standards shall be established for each dam to cover inspections, monitoring of fluid-retaining structures, and testing c discharge facilities.** | | | | X | | OMS appears to cover most items except qualification/training of inspectors and procedures for correction of deficiencies. | 2005 survey undertaken, but no apparent action as a result. | | |
| | 3.4.1b | **The level of surveillance shall be based on the Consequence classification of the dam** | X | | | | | | | | |
| 3.4.2 | **Regular Inspections** | | | | | | | | | | |
| | 3.4.2a | **In order to obtain baseline data, an initial inspection shall be performed on a new dam prior to the commencement of initial filling** | N/A | | | | | | | | |
| | 3.4.2b | **Periodic inspections shall be performed to determine the condition of integral portions of the fluid-retaining structure.** | | | | X | | | OMS manual specifies frequent inspections but inspection records were not available for review. | | |
| | 3.4.2c | **Appropriate investigations, as outlined in Section 2, shall be undertaken of all potential deficiencies disclosed by the regular inspections.** | | | X | | | | Piezometers at the toe of Strutt Lake Dam have degraded and readings are not taken. | | |
| | 3.4.2d | **Annual inspections shall be made of all operating tailings dams** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| 3.4.3 | **Special Inspections** | | | | | | | | | | |
| | 3.4.3a | **Special inspections shall be performed following potentially damaging events.** | X | | | | | NTPC to provide specific report on Freeboard Dyke 1 failure. | | | |
| 3.4.4 | **Instrumentation** | | | | | | | | | | |
| | 3.4.4a | **Initial readings of all instruments shall be made and formalized as baseline data.** | | | X | | | | No record of initial readings of piezometers at toe of Strutt Lake | | |
| | 3.4.4b | **Instrumentation shall be monitored, evaluated and maintained, and the data shall be compared with the previous readings and expected design values.** | | | | | X | | Piezometers at the toe of Strutt Lake Dam not maintained and no readings taken since installation. | | |
| 3.4.5 | **Tests** | | | | | | | | | | |
| | 3.4.5a | **All operating equipment and facilities necessary to pass the IDF shall be inspected and tested annually to ensure that they will function as required** | X | | | | | Overflow weir with no mechanical equipment. | | | |
| **4.0** | **EMERGENCY PREPAREDNESS** | | | | | | | | | | |
| 4.1 | **GENERAL** | | | | | | | | | | |
| | 4.1a | **Potential emergencies at a dam shall be identified and evaluated, with consideration of the consequences of failure, so that appropriate preventative or remedial actions can be taken.** | X | | | | | Snare Hydro Emergency Preparedness Manual | | | |
| | 4.1b | **An Emergency Preparedness Plan (EPP) shall be prepared, tested, issued and maintained for any dam whose failure could be expected to result in loss of life as well as for any dam for which advanced warning would reduce upstream or downstream damage.** | | | | X | | Snare Hydro Emergency Preparedness Manual | No record of plan testing or personnel training | | |

## Table 14-5:  2006 Dam Safety Review
## Conformance of Snare Forks with CDA Dam Safety Guidelines

**NON-CONFORMANCE =  procedural, operational or maintenance aspect.**

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| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.1c | **A notification process shall be initiated as specified in the EPP, immediately upon finding a hazardous condition that could lead to a dam breach, or upon discovering a potential dam breach or dam breach in progress.** | | X | | | | Snare Hydro Emergency Preparedness Manual | EPP needs updating; see text for details. | | |
| | 4.1d | **Where preventative actions are available, these actions shall be initiated, as appropriate, to prevent failure or to limit damages where failure is inevitable.** | X | | | | | Snare Hydro Emergency Preparedness Manual | | | |
| 4.2 | **EMERGENCY PREPAREDNESS PLAN** | | | | | | | | | | |
| 4.2.1 | **Development of an EPP** | | | | | | | | | | |
| | 4.2.1a | **An EPP shall describe the actions to be taken by the dam owner and operator in an emergency.  The EPP shall assign responsibility for each action to an individual (identified by organizational position) and/or backup.** | | | | X | | Snare Hydro EPP manual | EPP needs updating; see text for details. | | |
| | 4.2.1b | **Input from, and interfaces with, other agencies and affected parties shall be included in the EPP, as appropriate.** | | | | X | | | EPP needs updating; see text for details. | | |
| | 4.2.1c | **Copies of the EPP, or summaries of relevant information shall be provided to those who have responsibilities under the plan.** | | | | X | | | Distribution of the EPP is not controlled. | | |
| 4.2.2 | **Contents of an EPP** | | | | | | | | | | |
| | 4.2.2a | **The EPP shall include the following procedures and information:** | | | | | | Snare Hydro Emergency Preparedness Manual | | | |
| | 4.2.2a.1 | **- Emergency notification and evaluation;** | | | | X | | | Affected parties and positions not adequately presented in EPP. | | |
| | 4.2.2a.2 | **- Preventative actions (where available);** | | X | | | | | | | |
| | 4.2.2a.3 | **- Notification procedure;** | | | | X | | | Affected parties and positions not adequately presented in EPP. | | |
| | 4.2.2a.4 | **- Notification flowchart;** | | | | X | | | Affected parties and positions not adequately presented in EPP. | | |
| | 4.2.2a.5 | **- Communication systems;** | X | | | | | | | | |
| | 4.2.2a.6 | **- Access to site;** | X | | | | | | | | |
| | 4.2.2a.7 | **- Response during periods of darkness;** | X | | | | | | | | |
| | 4.2.2a.8 | **- Response during periods of adverse weather;** | X | | | | | | | | |
| | 4.2.2a.9 | **- Sources of equipment;** | | X | | | | | | | |
| | 4.2.2a.10 | **- Stockpiling supplies and materials** | | X | | | | | | | |
| | 4.2.2a.11 | **- Emergency power sources, if required;** | | X | | | | | | | |
| | 4.2.2a.12 | **- Inundation maps;** | | | | X | | | Add inundation maps | | |
| | 4.2.2a.13 | **- Warning systems (if used).** | | X | | | | | | | |
| 4.2.3 | **Maintenance and Testing of the EPP** | | | | | | | | | | |
| | 4.2.3a | **The EPP shall be issued to those affected, and all registered copies of the EPP shall be updated.** | | | X | | | | No record of document distribution or updating. | | |
| | 4.2.3b | **The EPP shall be tested.** | | | X | | | | No documentation of annual testing prior to EPP implementation during the 2006 dyke breach at Snare Forks. | | |
| | 4.2.3c | **For dams under construction, the EPP shall be reviewed annually and updated as appropriate** | N/A | | | | | | | | |
| 4.2.4 | **Training** | | | | | | | | | | |
| | 4.2.4a | **Training shall be provided to ensure that dam personnel involved in the EPP are thoroughly familiar with all elements of the EPP, the availability of equipment, and their responsibilities and duties** | | | | X | | | No documentation of Operator training available for review. | | |
| 4.3 | **INUNDATION STUDIES** | | | | | | | | | | |
| | 4.3a | **A dam breach inundation study shall be carried out for all dams that clearly require EPPs (see Section 4.1) and for dams where it is not obvious whether or not an EPP is needed** | X | | | | | 2000 DSR | | | |
| | 4.3b | **The inundation study shall be based on assumptions that will indicate all areas that could be flooded for the most severe combination of reasonably possible conditions** | X | | | | | 2000 DSR | | | |
| **5.0** | **EARTHQUAKES** | | | | | | | | | | |
| | 5.0a | **Dams shall be designed and evaluated to withstand ground motions associated with a Maximum Design Earthquake (MDE), without release of the reservoir.** | X | | | | | This report | MDE based on 1000 year earthquake | | |
| | 5.0b | **Selection of the MDE for a dam shall be based on the consequences of dam failure** | X | | | | | This report | Ditto | | |
| **6.0** | **FLOODS** | | | | | | | | | | |
| 6.1 | **GENERAL** | | | | | | | | | | |
| | 6.1a | **Dams shall be designed and evaluated to safely pass an Inflow Design Flood (IDF).  Selection of the IDF for a dam shall be based on the consequences of failure.** | X | | | | | 2000 DSR | | | |
| | 6.1b | **For new dams with very high or high consequences of failure, the maximum design floods at the dam site shall be evaluated by both statistical analysis and deterministic methods** | N/A | | | | | | Not applicable (not a new dam) | | |
| 6.2 | **STATISTICAL FLOOD ANALYSIS** | | | | | | | | | | |
| | 6.2a | **If the IDF is statistically determined, the reliability of existing statistical flood analysis shall be confirmed or a new statistical flood analysis shall be developed** | X | | | | | This report | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6.2b | **If an unusual event has been recorded since the statistical flood was evaluated, or if the duration of the available hydrological data has increased by more than 50%, a new statistical flood analysis shall be carried out.** | N/A | | | | | | No new hydrological events occurred since previous evaluation; data since 2000 reviewed for this DSR. | | |
| 6.3 | | **PROBABLE MAXIMUM FLOOD (PMF)** | | | | | | | | | |
| | 6.3a | **A Probable Maximum Flood (PMF) study shall consider the most severe "reasonably possible" combination of the following phenomena on the watershed upstream of the structure under study** | N/A | | | | | | ID < PMF | | |
| | 6.3a.1 | **- Rainstorm;** | N/A | | | | | | | | |
| | 6.3a.2 | **- Snow accumulation;** | N/A | | | | | | | | |
| | 6.3a.3 | **- Melt rate;** | N/A | | | | | | | | |
| | 6.3a.4 | **- Initial basin conditions (e.g. soil moisture, lake and river levels);** | N/A | | | | | | | | |
| | 6.3a.5 | **- Prestorm.** | N/A | | | | | | | | |
| | 6.3b | **When the PMF is identified as the IDF for a particular project, the acceptability of any previous PMF analysis must be confirmed or a new PMF analysis undertaken.** | N/A | | | | | | | | |
| 7.0 | | **DISCHARGE FACILITIES** | | | | | | | | | |
| 7.1 | | **FLOW CAPACITY OF HYDRAULIC STRUCTURES** | | | | | | | | | |
| | 7.1a | **The discharge facilities shall be designed or modified to be capable of passing the IDF, taking into account the routing effect of the reservoir, without the reservoir level infringing on the freeboard established in Section 7.2 for this condition.** | X | | | | | 2000 DSR | | | |
| | 7.1b | **New dams shall be designed such that:** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 7.1b.1 | **- The outflow structure handles ice and debris** | N/A | | | | | | | | |
| | 7.1b.2 | **- Water conveyance structures resist the anticipated high velocities** | N/A | | | | | | | | |
| | 7.1b.3 | **- Energy dissipation structures protect the dam during the passages of the IDF** | N/A | | | | | | | | |
| 7.2 | | **FREEBOARD** | | | | | | | | | |
| | 7.2a | **Sufficient freeboard shall be provided so that under all operating conditions, including those during extreme floods or extreme wind conditions the percentage of waves that could overtop the dam is limited to an amount that would not lead to dam failure.** | | | | | X | | Freeboard dyke crests locally lower than maximum operating level. | | All side dams should be raised above reservoir level to accommodate future settlement. |
| | 7.2b | **The maximum reservoir level shall be at or below the top of the impervious core for embankment dams.** | X | | | | | 2000 DSR | Snare Forks and Strutt Lake Dams only structures with cores. | | |
| 7.3 | | **OPERATION DURING FLOODS** | | | | | | | | | |
| | 7.3a | **All discharge facilities shall be operated at all times according to a set of pre-determined rules. The development of such rules shall consider the safe passage of all hydrological events, including the IDF** | X | | | | | | Discharge facility is fixed overflow weir with no mechanical equipment. | | |
| | 7.3b | **For new dams, rule curves shall be established for operation during the flood season, such that all floods, including the IDF, can be passed safely.** | N/A | | | | | | Not applicable (not a new dam) | | |
| 7.4 | | **OPERATION OF FLOW CONTROL EQUIPMENT** | | | | | | | | | |
| | 7.4a | **The conditions under which the spillway, discharge facilities and power intake must operate, as well as the level of automation associated with the equipment, shall be determined on a site-specific basis.** | X | | | | | | Discharge facility is fixed overflow weir with no mechanical equipment. Intake gate can be closed automatically or remotely in event of a penstock failure. | | |
| | 7.4b | **All flow control equipment shall be designed to be capable of opening and closing under required operating conditions. The required service shall be determined by a site-specific evaluation of requirements.** | X | | | | | | Intake gates are annually tested for remote closure. | | |
| 7.5 | | **INSTRUMENTATION AND CONTROL** | | | | | | | | | |
| | 7.5a | **Equipment on Very High and High Consequence structures shall be provided with instrumentation to enable local and/or remote monitoring of conditions at the hydraulic structures** | N/A | | | | | | | | |
| 7.6 | | **EMERGENCY EQUIPMENT** | | | | | | | | | |
| | 7.6a | **As a minimum, emergency power equipment shall be available for installation in a reasonable amount of time at Very High and High Consequence structures. Otherwise, permanent emergency power equipment shall be installed.** | X | | | | | | Emergency and backup power is available. | | |
| | 7.6b | **Controls and instrumentation shall permit operation and monitoring during power outage conditions for Very High and High Consequence structures** | N/A | | | | | | | | |
| 8.0 | | **GEOTECHNICAL CONSIDERATIONS** | | | | | | | | | |
| 8.1 | | **GEOTECHNICAL INVESTIGATIONS FOR NEW DAMS** | | | | | | | | | |
| | 8.1a | **Adequate geotechnical investigations shall be carried out on the site selected for a new dam** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 8.1b | **A permanent record or log shall be kept of all inspections, investigation reports, drawings and design reports.** | | | | X | | | Inspection records not available for review | | |
| 8.2 | | **EMBANKMENT DAMS AND SOIL FOUNDATIONS** | | | | | | | | | |
| 8.2.1 | | **Monitoring and Instrumentation** | | | | | | | | | |
| | 8.2.1a | **Sufficient instrumentation for the embankment dam and foundation shall be provided, commensurate with the Consequence Category, so that the performance can be adequately monitored and dam safety can be evaluated.** | X | | | | | | | | |
| | 8.2.1b | **For new dams, sufficient instrumentation shall be provided to adequately monitor the dam and evaluate its performance.** | N/A | | | | | | Not applicable (not a new dam) | | |
| 8.2.2 | | **Stability and Deformation** | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

# Table 14-5: 2006 Dam Safety Review
# Conformance of Snare Forks with CDA Dam Safety Guidelines

**NON-CONFORMANCE = procedural, operational or maintenance aspect.**

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| CDA Sect. No. | DSR Proj. ID# | **Guiding Principles**(CDA Dam Safety Guidelines, boldtext "Requirements") | Conformance | Meets Intent | Non-Conformance | Potential Deficiency | Actual Deficiency | **Reference** | Description & Comments | Supplementary Notes (if any) | Recommendation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.2.2a | **The slopes of the dam and the abutment shall be designed so that the dam, foundation and abutments are stable under all stages of construction, reservoir levels and operating conditions.** | X | | | | | | Rock foundation and abutments for Snare Falls and Strutt Lake Dams. Freeboard Dykes founded on permafrost effected lacustrine soils. | | |
| | 8.2.2b | **The slopes of the dam and the abutment shall be designed not to cause unacceptable deformation in the dam or foundation.** | X | | | | | | | | |
| | 8.2.2c | **The stability of reservoir slopes shall be evaluated under seismic loads, heavy rainfall, rapid drawdown and any other conditions, if slope failure could induce waves that pose an unacceptable risk to public safety, the dam or its appurtenant structures.** | X | | | | | | Reservoir rim constitutes low rock relief. | | |
| | 8.2.2d | **If necessary, such slopes shall be stabilized or the public otherwise protected from the effects of slope failure.** | X | | | | | | Ditto | | |
| | 8.2.2e | **Any material stockpiled upstream of a tailings dam shall be maintained in a stable configuration, if it can affect the stability of the dam or its appurtenant structures either directly or by destabilising stored or stockpiled tailings.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| | 8.2.2f | **Sufficient freeboard shall be provided to accommodate expected settlement of the crest and cracks caused by frost action.** | | | | | X | | Crest settlements indicated by 2005 survey not addressed. | | |
| **8.2.3** | **Seepage and Drainage Control** | | | | | | | | | | |
| | 8.2.3a | **Filters shall be placed between materials where otherwise significant migration of particles by seepage forces would be possible.** | | X | | | | | Sand filters provided between core and shell material of Snare Forks and Strutt Lake Dams | | |
| | 8.2.3b | **Construction of embankments, structural cutoffs and foundation treatment shall be staged such that adequate filters are in place.** | | X | | | | | | | |
| | 8.2.3c | **Filter provisions shall be adequate to accommodate the movements and avoid erosion induced by the design earthquake.** | | X | | | | | Dam stable under low seismic loading | | |
| | 8.2.3d | **The hydraulic gradients in the dam, in foundation abutments and along conduits, shall be low enough to prevent piping and heave in the existing material** | | X | | | | | | | |
| | 8.2.3e | **The flow capacity of filters and drains shall be designed to accommodate the maximum anticipated seepage.** | | X | | | | | Shells of Snare Forks and Strutt Lake Dams are rockfill and likely free draining. | | |
| **8.2.4** | **Cracking** | | | | | | | | | | |
| | 8.2.4a | **The dam shall be designed to retain the reservoir safely in spite of any cracking that may be induced by settlement or hydraulic fracturing.** | | X | | | | | There is no evidence that excessive settlement or hydraulic fracturing has caused cracking; cracks have not been identified in the past at Snare Forks and Strutt Lake Dams. | | |
| **8.2.5** | **Surface Erosion** | | | | | | | | | | |
| | 8.2.5a | **The upstream slopes of the dam and its abutments shall be provided with adequate protection to guard against erosion and possible breaching due to wave and ice action and against burrowing animals such as beaver and muskrat. Failure of riprap must not result in dam failure.** | X | | | | | | | | |
| | 8.2.5b | **The downstream slopes shall be protected where necessary against the erosive action of runoff, seepage flows, traffic, frost and burrowing animals.** | X | | | | | | | | |
| | 8.2.5c | **Inlet and outlet channels for spillways and conduits shall be adequately protected against erosior** | X | | | | | | Rock channel provided | | |
| | 8.2.5d | **Temporary and permanent slopes of the embankments and abutments shall be adequately protected against wave action, runoff and seepage flows during construction** | N/A | | | | | | Not applicable (construction complete) | | |
| **8.2.6** | **Liquefaction** | | | | | | | | | | |
| | 8.2.6a | **All embankment and foundation materials susceptible to liquefaction shall be identifiec** | N/A | | | | | | | | |
| | 8.2.6b | **If liquefaction is possible under static conditions or probable under design earthquake loading, the post-liquefaction stability of the dam shall be evaluated.** | N/A | | | | | | | | |
| | 8.2.6c | **If unacceptable flowsliding is probable following liquefaction, appropriate remedial measures shall be undertaken to ensure dam failure does not occur.** | N/A | | | | | | | | |
| **8.2.7** | **Earthquake Resistance** | | | | | | | | | | |
| | 8.2.7a | **The dam, appurtenant structures, foundation and abutments shall be designed to resist the forces associated with the Maximum Design Earthquake (MDE).** | | | X | | | 2000 DSR, this report. | Intake stability not assessed. | | |
| | 8.2.7b | **Embankments and foundations that are required to impound temporary reservoirs during construction shall be designed to resist forces associated with the MDE selected for their design** | N/A | | | | | | Not applicable (not a new dam) | | |
| **8.3** | **DAMS ON ROCK FOUNDATIONS** | | | | | | | | | | |
| **8.3.1** | **Foundation Stability** | | | | | | | | | | |
| | 8.3.1a | **For new dams rock foundations shall be excavated to a depth, and grouted, such that they have sufficient strength, watertightness and stiffness:** | N/A | | | | | | Not applicable (not a new dam) | | |
| | 8.3.1a.1 | **- to support all stages of construction and initial reservoir filling and drawdowr** | N/A | | | | | | Ditto | | |
| | 8.3.1a.2 | **- to provide adequate stability under design loads for the dam, appurtenances, abutments and foundatior** | N/A | | | | | | Ditto | | |
| | 8.3.1a.3 | **- to limit deformations to acceptable values.** | N/A | | | | | | Ditto | | |
| **8.3.2** | **Shear Strength Parameters** | | | | | | | | | | |

Based on the Dam Safety Guidelines published in 1999 by the Canadian Dam Association.

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## Conformance of Snare Forks with CDA Dam Safety Guidelines

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8.3.2a | **The dam shall be designed such that the shear strength of the rock foundations is adequate at all stages of construction, initial reservoir filling and drawdown, to ensure the stability of a dam at and within its foundation.** | X | | | | | | Satisfactory operating history indicates that foundation is adequate at Snare Forks and Strutt Lake Dams. | | |
| 8.3.3 | **Seepage and Drainage** | | | | | | | | | | |
| | 8.3.3a | **If the rock is not of sufficient quality, adequate protection shall be provided to protect against internal erosion, leaching, or solution effects in foundations or abutments.** | X | | | | | | Satisfactory operating history indicates that foundation is adequate at Snare Forks and Strutt Lake Dams. | | |
| | 8.3.3b | **The foundation and abutment grouting and drainage systems shall maintain foundation water pressures at acceptable levels.** | | X | | | | | No grouting or drainage of bedrock are shown on drawings. | | |
| | 8.3.3c | **Where embankments are constructed on rock foundations, the treatment of the foundation shall be compatible with the embankment materials, such that migration of the embankment material is prevented.** | | X | | | | | No foundation treatment shown on drawings. Satisfactory performance indicates adequate treatment. | | |
| | 8.3.3d | **Provision shall be made to control unacceptable quality and quantity of seepage for all stages of construction, initial reservoir filling, operation and drawdown.** | | X | | | | | Satisfactory performance indicates adequate control. | | |
| 8.4 | **DAMS ON PERMAFROST** | | | | | | | | | | |
| | 8.4a | **Dams on permafrost shall meet the same stability requirements as other embankment dams, and shall remain stable in spite of large foundation settlements.** | | X | | | | | Freeboard Dykes low structures, with no stability realted problems. | | |
| | 8.4b | **The freeboard shall be adequate to accommodate the expected settlement.** | | | | | X | | Freeboard Dyke overtopped in 2006 due to crest settlement | | |
| | 8.4c | **The fill zones shall have sufficient integrity to prevent piping and limit seepage to an acceptable amount.** | | | | X | | | Reverse filter required at the toe of Freeboard Dyke 2 at locations of small boils. | | |
| 8.5 | **APPURTENANT STRUCTURES** | | | | | | | | | | |
| 8.5.1 | **Foundation Movement** | | | | | | | | | | |
| | 8.5.1a | ***In situ* foundations and abutments as well as embankments and backfill, through which or on which an appurtenant hydraulic structure will be constructed, should be designed to be free from gravity-driven movements that would impair the operational capability of the structure or lead to structural damage such as excessive cracking, deformation, deflection, damage to joints, threaten the structural integrity and hydraulic performance. Likewise, the foundations and embankment shall be protected from any potential adverse effects of any leakage from any conduit or structures.** | | X | | | | | No record of movements of appurtenant structures or abutments. | | |
| | 8.5.1b | **The foundation of an appurtenant hydraulic structure, whether *in situ* or compacted earthen materials, shall be designed to avoid differential settlement or heave that would either damage seals, waterstops or joints, or misalign or crack slabs or monoliths** | | X | | | | | Intake on rock | | |
| 8.5.2 | **Slope Stability** | | | | | | | | | | |
| | 8.5.2a | **Slopes flanking the approach and exit channels of an appurtenant hydraulic structure shall be designed to be stable to the extent that any instability under the broad category of gravity-driven soil and rock movement does not restrict these channels.** | X | | | | | | Intake flanked by Strutt Lake Dam slopes. | | |
| 8.5.3 | **Seepage** | | | | | | | | | | |
| | 8.5.3a | **The impervious or seepage-control zone immediately underlying or enclosing the upstream portion of an appurtenant hydraulic structure, including components such as cut-off, core trench or upstream blanket shall be designed to be free of localised concentrations of seepage that could lead to piping. In the case of new dams, this impervious or seepage-control zone shall be free of deleterious hydraulic and material conditions which individually or in combination could lead to excessive seepage and piping** | | X | | | | | Performance record indicates adequate seepage control at control structures. | | |
| 8.6 | **GABION, ROCK CRIB AND TIMBER STRUCTURES** | | | | | | | | | | |
| | 8.6a | **Gabion, rock crib and timber dams, and their foundations, shall meet the same stability requirements as all dams. In addition, the timber shall maintain durability and be capable of transmitting the induced loads** | N/A | | | | | | | | |
| | 8.6b | **Gabion dams shall incorporate a suitable filter as a preventive measure against undermining of the foundation soil material. The wire comprising the gabion mesh shall be adequately sized and protected against corrosion and shall be designed to retain its integrity for the planned life of the structure** | N/A | | | | | | | | |
| 8.7 | **MEMBRANE-FACED ROCKFILL DAMS** | | | | | | | | | | |
| | 8.7a | **Membrane-faced rockfill dams and their foundations shall meet the same stability requirements as other embankment dams. The integrity of the upstream membrane shall be designed to minimize the effects of settlement, ultraviolet deterioration and any other damage that would permit excessive leakage.** | N/A | | | | | | Not a membrane faced rockfill dam. | | |
| | 8.7b | **Seepage or leakage through the membrane face shall be limited to values that will not adversely affect dam stability.** | N/A | | | | | | | | |
| 8.8 | **FLOW-THROUGH ROCKFILL DAMS** | | | | | | | | | | |
| | 8.8a | **For the design flood, flow-through rockfill dams shall be designed to withstand the combined effects of the action of the seepage emerging from the downstream face, along with any overflow without local or massive movement of rock particles.** | N/A | | | | | | Not a flow through Rockfill dam | | |
| 9.0 | **CONCRETE STRUCTURES** | | | | | | | | | | |
| 9.1 | **GENERAL** | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.1a | **The level of design or safety assessment for concrete dams and other water-retaining structures shall take into account the consequences of failure of the structure** | | | | X | | 2000 DSR, this report | Spillway stability considered adequate<br>Intake stability not assessed | Insufficient data available to KCBL | Intake stability assessment required |
| **9.2** | **CONDITION OF STRUCTURES AND SITES** | | | | | | | | | | |
| | 9.2a | **The strength and condition of the dam and foundation shall be determined to the extent required for the design of a new dam or analysis of an existing dam.** | | | | X | | | see 9.1a | | |
| | 9.2b | **If the concrete appears to be damaged or weakened, tests shall be carried out to determine its strength parameters, or suitably conservative assumptions made in the analysis of its safety** | X | | | | | 2000 DSR, this report | Spillway concrete not accessible<br>Intake concrete appears sound | | Spillway inspection is required at low water levels |
| | 9.2c | **For High and Very High Consequence dams, sufficient instrumentation shall be provided for the structure and foundation, to allow performance to be monitored and safety to be evaluated.** | X | | | | | Snare Emergency Preparedness Plan Manual | Instrumentation of the spillway and intake is not considered necessary | | |
| **9.3** | **LOADS** | | | | | | | | | | |
| | 9.3a | **The following loads shall be considered in the design or assessment of concrete structures** | | | | X | | | see 9.1a | | |
| | 9.3a.1 | **- Dead loads of permanent structures and equipment (D);** | | | | X | | | see 9.1a | | |
| | 9.3a.2 | **- Maximum normal headwater level (H) combined ,with the most critical concurrent tailwater level** | | | | X | | | see 9.1a | | |
| | 9.3a.3 | **- Maximum flood headwater level ($H_F$) based on the Inflow Design Flood (IDF) with corresponding tailwater levels;** | | | | X | | | see 9.1a | | |
| | 9.3a.4 | **- Internal water pressure and foundation uplift (U);** | | | | X | | | see 9.1a | | |
| | 9.3a.5 | **- Static and dynamic thrust created by an ice sheet, for reservoirs subject to freezing (I)** | | | | X | | | see 9.1a | | |
| | 9.3a.6 | **- Vertical and horizontal loading due to rock or soil backfill, including potential effects of liquefaction, as well as loads from silt deposited against the structure (S);** | | | | X | | | see 9.1a | | |
| | 9.3a.7 | **- Maximum Design Earthquake (Q);** | | | | X | | | see 9.1a | | |
| | 9.3a.8 | **- Temperature-induced loads (T), for stability and stress analysis of concrete structures with grouted contraction joints, especially buttress and arch dams.** | N/A | | | | | | | | |
| **9.4** | **LOAD COMBINATIONS** | | | | | | | | | | |
| **9.4.1** | **Usual Loading** | | | | | | | | | | |
| | 9.4.1a | **Permanent and operating loads shall be considered for both summer and winter conditions including self-weight, ice, silt, earth pressure, and the normal maximum operating water level with appropriate uplift pressures and tailwater level (D+H+I+S+U).** | | | | X | | | see 9.1a | | |
| **9.4.2** | **Unusual Loading** | | | | | | | | | | |
| | 9.4.2a | **Where earthquake-induced cracking at the rock concrete interface or any weak section is identified, a stability analysis shall be carried out to see whether the structure in its post-earthquake condition is still capable of resisting the Usual Loading (D+H+S+$U_{PQ}$).** | | | | X | | | see 9.1a | | |
| **9.4.3** | **Flood Loading** | | | | | | | | | | |
| | 9.4.3a | **Permanent and operating loads of the Usual Loading, except for ice loading, shall be considered in conjunction with reservoir and tailwater levels and uplift resulting from the passage of the Inflow Design Flood (IDF) (D+H+S+$U_F$).** | | | | X | | | see 9.1a | | |
| **9.4.4** | **Earthquake Loading** | | | | | | | | | | |
| | 9.4.4a | **Permanent and operating loads of the Usual Loading case shall be considered in conjunction with the seismic loads of the Maximum Design Earthquake (MDE) (D+H+S+Q+$U_Q$).** | | | | X | | | see 9.1a | | |
| **9.4.5** | **Temperature Loading** | | | | | | | | | | |
| | 9.4.5a | **Permanent and operating loads from the Usual Loading case shall be considered in conjunction with temperature loads for buttress and arch dams (D+H+I+S+U+T).** | N/A | | | | | | | | |
| **9.5** | **DESIGN AND ANALYSIS** | | | | | | | | | | |
| | 9.5a | **Concrete dams shall be designed to resist and prevent** | | | | X | | | see 9.1a | | |
| | 9.5a.1 | **- Sliding at the dam-foundation interface, within the dam and at any plane in the foundation** | | | | X | | | see 9.1a | | |
| | 9.5a.2 | **- Overturning;** | | | | X | | | see 9.1a | | |
| | 9.5a.3 | **- Overstressing of the concrete dam or foundation;** | | | | X | | | see 9.1a | | |
| | 9.5a.4 | **- Excessive seepage through the foundation or through joints in the concrete dam** | | | | X | | | see 9.1a | | |
| | 9.5b | **Safety analyses for existing concrete dams shall take into account their ability to resist and prevent the above conditions.** | | | | X | | | see 9.1a | | |
| | 9.5c | **Stresses and stability of a concrete gravity dam shall be evaluated for ground motions in the upstream-downstream direction. If the geometry suggests potential "pounding" of adjacent blocks, cross-valley analyses shall be undertaken.** | | | | X | | | see 9.1a | | |
| | 9.5d | **Stresses and stability of a buttress dam shall be evaluated for ground motions in the upstream-downstream as well as the cross-valley directions** | | | | X | | | see 9.1a | | |
| **9.6** | **PERFORMANCE INDICATORS** | | | | | | | | | | |
| | 9.6a | **The design and assessment of concrete dams and other water-retaining structures shall be based on performance indicators such as:** | | | | X | | | see 9.1a | | |
| | 9.6a.1 | **- Position of resultant force;** | | | | X | | | see 9.1a | | |
| | 9.6a.2 | **- Normal stresses at the heel and the toe;** | | | | X | | | see 9.1a | | |
| | 9.6a.3 | **- Average shear stresses acting on the surface;** | | | | X | | | see 9.1a | | |
| | 9.6a.4 | **- Calculated sliding factors and strength factors;** | | | | X | | | see 9.1a | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.6a.5 | **- Observed conditions of structure and site** | X | | | | | 2000 DSR, this report | | | |
| **9.7** | | **ACCEPTANCE CRITERIA** | | | | | | | | | |
| | 9.7a | **Concrete gravity, buttress and arch dams and their foundations shall have adequate sliding resistance to withstand all reasonable loads and load combinations that could occur.** | | | | X | | | see 9.1a | | |
| | 9.7b | **The concrete must have sufficient strength that the loads will not result in excessive deformations or overstressing.** | | | | X | | | see 9.1a | | |
| | 9.7c | **During and after extreme events such as the IDF and the MDE, the dam shall continue to safely retain the reservoir water.** | | | | X | | | see 9.1a | | |
| | 9.7d | **The level of safety of appurtenant structures shall be compatible with the consequences of their failure.** | N/A | | | | | | No appurtenant concrete structures governed by DSR requirements | | |
| | 9.7e | **The effects of static and dynamic (seismic) loadings on support structures for mechanical and electrical equipment that relate to dam safety shall be examined to ensure that structural integrity and functionality are preserved.** | | X | | | | Not assessed but MDE is low | | | |
| **9.8** | | **ROLLER-COMPACTED CONCRETE (RCC) DAMS** | | | | | | | | | |
| | 9.8a | **Roller-compacted concrete (RCC) dams shall meet the same stability and performance specifications as conventional concrete gravity dams.** | N/A | | | | | | | | |
| **10.0** | | **RESERVOIR AND ENVIRONMENT** | | | | | | | | | |
| **10.1** | | **RESERVOIR DEBRIS AND ICE** | | | | | | | | | |
| | 10.1a | **Reservoir debris and ice shall be managed in such a way that they do not constitute an unacceptable risk to dam safety.** | X | | | | | | Performance record indicates adequate debris and ice management. | | |
| **10.2** | | **RESERVOIR RIM** | | | | | | | | | |
| | 10.2a | **Unstable slopes or slopes which are potentially unstable under extreme loading, or rapid reservoir drawdown condition around the reservoir rim shall be monitored and treated if necessary so that they do not constitute an unacceptable risk to the safety of the dam.** | N/A | | | | | | | | |
| | 10.2b | **Any point on the rim of the reservoir which forms a natural barrier shall be treated in the same manner as a dam, if its failure could release the reservoir** | N/A | | | | | | | | |
| | 10.2c | **Excessive seepage through the reservoir rim shall be controlled so that it does not constitute an unacceptable risk to th safety of the dam or reservoir.** | N/A | | | | | | | | |
| **10.3** | | **WATER QUALITY** | | | | | | | | | |
| | 10.3a | **Consideration shall be given to monitoring detrimental effects on structural elements of the dam from chemical interaction between groundwater, reservoir water, natural soil, and all dam materials, and to taking necessary protective measures.** | | X | | | | | No report of water quality issue in many years of operation. | | |
| **10.4** | | **SEDIMENTATION AND SILTING** | | | | | | | | | |
| | 10.4a | **Silt deposition near the dam and discharge facilities shall be monitored as appropriate and if the continued deposition could impair the safe routing of floods or the stability of the dam, appropriate remedial measures shall be taken.** | | X | | | | | No evidence of siltation at any structure. | | |
| | 10.4b | **Tailings shall not be deposited in such a manner as to hinder the operation or stability of a dam and its appurtenant structures.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **10.5** | | **RESERVOIR DRAWDOWN CAPABILITY** | | | | | | | | | |
| | 10.5a | **At dams that are subject to severe damage by earthquake or landslides, or where a high potential for internal erosion exists, outlet facilities shall be provided to quickly lower the reservoir to a safe level for the dam in its damaged state.** | X | | | | | | Low design earthquake load, very small potential for landslide | | |
| **10.6** | | **ECOLOGY** | | | | | | | | | |
| | 10.6a | **The dam shall be monitored for dam safety hazards presented by animals, birds, vegetation or other organisms, and protective action taken if required.** | X | | | | | | Maintenance required locally to remove vegetation. | | |
| **10.7** | | **REHANDLING OF TAILINGS** | | | | | | | | | |
| | 10.7a | **The rehandling of tailings or other materials upstream of, or adjacent to a dam, shall be undertaken in such a manner that the safety or safe operation of a dam and appurtenances is not impaired.** | N/A | | | | | | Not applicable (not a tailings dam) | | |
| **11.0** | | **CONSTRUCTION** | | | | | | | | | |
| | 11a | **An Engineer shall ensure that the project specifications are strictly adhered to. Any deviation from the prescribed specifications are allowed only if approved by the design engineer** | N/A | | | | | | | | |
| | 11b | **The Engineer shall document and approve all phases of the project construction** | N/A | | | | | | | | |
| | 11c | **Temporary construction facilities shall be constructed such that there is no adverse impact on the safety of the dam or appurtenant structures.** | N/A | | | | | | | | |

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